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Intensifying Agriculture

Important factors which govern sugar production are climate, land area, labor, water, and nitrogen.

In cost accounting we usually give the monetary cost per ton of sugar or per ton of cane. We express yields ordinarily in terms of tons of cane or tons of sugar per acre.

It is generally conceded that on unirrigated plantations yields are limited by adverse temperature or lack of sufficient rainfall. On irrigated lands, enjoying for the most part more favorable temperature, yields are held in check by a lack of sufficient irrigation water. Probably no irrigated plantation has, throughout the year, all the irrigation water that it would like. The labor supply also affects yields. Even under what might be a normal adequate supply, there are seasons of the year when extra labor could be used to great advantage and with telling effect upon yields of cane and sugar. Labor, without question, is a limiting factor in production, just as water is.

It is suggested, therefore, that we study yields with respect to what is required to produce these yields in the terms of labor and water and other essentials.

It has been shown in various reports during the past few years that it takes in round numbers about one million gallons of water on the average irrigated plantation to produce a ton of sugar. This figure includes rainfall as well as irrigation water and embraces a large part of the seepage losses in ditches.

If 40,000 laborers, working 250 days a year, produce annually 500,000 tons of sugar, each ton of sugar has called for 20 man-days of labor. This, as a rough average figure, is subject to considerable variation, say 15 to 25, or perhaps even wider limits.

Purchased supplies are not a limiting factor in the same sense that labor and water are, for we are drawing upon sources which are not restricted and we are concerned, not with adjusting our operations to conform with a given inelastic supply, but with purchasing such an amount of material as can be used

to economical advantage in connection with limited supplies of labor and water and land.

For instance, if we are using 150 pounds of nitrogen per acre and are getting six tons of sugar, each ton of sugar is costing 25 pounds of nitrogen. In an effort to increase our yield we are at liberty, economically, to draw upon the world's supply of nitrogen at this rate for every ton of sugar we are able to increase our yields.

Such a course is not open to us when we consider either labor or water. If the six tons of sugar have cost us six million gallons of water, any proposed increase in the amount of water to be supplied per acre must very likely be accompanied by the development of more water, or by a reduction in the number of acres we are to hold under irrigation.

Any proposed change in our agricultural methods looking toward better results on an irrigated plantation must, therefore, be considered in its relation to:

(1) yield per acre
(2) yield per man-day of labor
(3) yield per million gallons of water.

If a field method is devised that affects the first of these favorably, it is sound only if it does not affect one of the other items adversely. We have nothing to gain by a method which produces more sugar per acre at a cost of more labor or more water per ton of sugar.

A method which calls for more labor per acre is admissible whenever it reduces the labor and water requirements per ton of sugar. The prime objective of a plantation is not to cultivate a given number of acres. A reduction in area as a means of obtaining better yields per *acre*, per *man-day of labor*, per *million gallons of irrigation water* is worth considering. Before an extensive sacrifice in area for the purposes named can be undertaken safely, a plantation must first determine, through experiments on a commercial scale, the high yield possibilities of its fields, and what these yields cost in labor and water *per ton of sugar*. The possible benefits that accrue from fallowing are to be given due consideration as a part of this plan.

Where adverse climatic conditions set a low limit on sugar yields, improvements in agricultural methods are to be directed along the lines of low cost of production *per acre*.

This is sometimes called "extensive" agriculture to distinguish it from intensive agriculture that seeks high acreage yields. But if we adopt the term we must not overlook the fact that, under the so-called "extensive" methods, we are merely intensifying our efforts in another direction, that of producing the highest practicable amount of sugar per man-day of labor, or per dollar of expense.

According to this viewpoint, all of our agriculture is, or should be, intensified. Taking a given set of plantation conditions — area, water, labor, nitrogen, and temperature — one may determine, through a careful diagnosis of the case, the weak link in the chain of raw materials we are to make into sugar cane. Then we intensify in the direction that takes full advantage of that factor which tends to limit production. Here we are concerned not so much with yield

per acre as with yield *per unit of limiting factor,* such as sugar per man-day of labor, or sugar per million gallons of water. If it takes 75 man-days of labor per acre to produce three tons of sugar, we become seriously concerned in reducing the labor per ton of sugar. If climatic conditions form a barrier that limits consideration of higher yields than three to four tons of sugar per acre, we intensify upon making every man-day of work count for all it can in sugar production. The elimination of unessential operations, the substitution of animal or motor power, the use of implements, or automatic irrigation, all tend to reduce the labor requirement, and hence invite consideration. Cane varieties that close in quickly and ratoon freely reduce weeding to a minimum and offer interesting possibilities.

The actual value in sugar of each field operation can be determined, or estimated carefully. Just as the plantation operating under favorable climatic conditions is concerned with commercial trials to determine the possibilities of high yields per acre, so a plantation operating under adverse conditions discovers the importance of systematic work which covers the various points already mentioned, and formulates field methods which are pertinent to its especial needs.

Sugar: 15.36 Tons per Acre on 288 Acres.

The Ewa Plantation Company this year has harvested five fields, covering an area of 288.81 acres, which have produced sugar at the average rate of 15.36 tons per acre.

These yields, obtained under plantation field conditions, set a new mark in sugar production. The variety was H 109. The treatment of these fields embraced four fundamental requirements for best results, namely: (a) heavy fertilization with nitrogenous salts, (b) adequate irrigation throughout the growing period of the cane, (c) the last application of fertilizer occurred practically one year before harvesting, and (d) the irrigation was stopped at 60 to 90 days before harvesting.

Of these fundamentals the first two work toward high yields of cane; the second two operate in ripening this cane so as to reduce the number of tons of cane per ton of sugar. The following data show the record of four individual fields with respect of three of these points:

Field	Nitrogen per Acre	Period Between Last Fertilization and Beginning of Harvest	Period Between Last Irrigation and Beginning of Harvest
16-A	271 lbs.	365 days	89 days
16-B	260 "	358 "	74 "
16-C	256 "	341 "	60 "
1-E	251 "	363 "	66 "

These figures are supplied by George F. Renton, Jr., Manager, Ewa Plantation Company, who furnishes other details bearing upon the results. The fifth field was harvested after the details on the other four had been supplied, and the information on that field is that "83.17 acres of plant cane yielded 107.53 tons of cane per acre, requiring but 6.95 tons of cane to make a ton of sugar, so that there were produced 15.35 tons of sugar per acre."

An interesting feature to be noted is that the Ewa Plantation Company has adopted the plan of expressing yields not only as tons-of-sugar-per-acre, but also as tons-of-sugar-per-acre-per-month. The way in which this operates toward making full use of growing time cannot be fully appreciated until the expression is put into use and yields are discussed on this basis of comparison. Mr. Renton's letter regarding the first four fields reads:

"Replying now to your letter of July 11, asking for information concerning high yields of certain fields at this place, I beg to submit the following data:

"The yields obtained were as follows:

Field 16-A	24.79 acres	15.25 tons sugar per acre
" 16-B	49.55 "	15.58 " " " "
" 16-C	72.50 "	15.14 " " " "
" 1-E	58.80 "	15.51 " " " "

FIELD 16-A (24.79 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting Field 16-A was harvested April 12th to 16th, 1920.

"(2) The field was planted July 10th to 14th, 1920. (A heavy rain of 1.85 inches occurred on July 12th.) The seed was unselected body seed from 12-months old cane (Fields 20-B and 9-A). It was planted butt to butt and required 61 bags per acre. It did not germinate well and 24 bags per acre of replant were required to make a solid stand. Strikebreakers (Hawaiian women and Boy Scouts) did the planting.

"(3) Irrigation rounds averaged 10.7 days from August 1st to November 1st. Heavy winter rains made irrigation unnecessary until March. From then until the following November the rounds averaged 16.42 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

" 'Third season' irrigation consisted of one round completed on March 16th, or 89 days before the field was harvested.

"The laboratory record gives the following juice analysis:

Tons can per ton sugar	7.23
Percent sucrose	14.86
Brix	20.78
Polarization	18.18
Purity	87.49

"The cane was well matured and ripe.

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. Eleven hundred and twenty-nine pounds per acre of 'F' fertilizer were applied, giving 113 pounds of nitrogen per acre, 34 pounds of K_2O, and 34 pounds of P_2O_5. Two doses of 508 pounds per acre of nitrate of soda were applied in the irrigation water finishing on March 23rd and June 13th. This made the field receive a total of 271 pounds of nitrogen.

"(5) There was a good growth of weeds to contend with, the charges being $3.00 per acre for this item.

"(6) Harvesting commenced on June 15th and was completed on June 21st, 1922, making the cane about 23 months old, 0.663 being the sugar per acre per month, 15.25 tons sugar per acre per crop, 110.28 tons cane per acre per crop.

FIELD 16-B (49.55 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting, Field 16-B was harvested April 6th to 14th, 1920.

"(2) The field was planted July 14th to July 25th in damp soil, following a 1.85-inch rain on July 12th. The seed was unselected body seed from 12-months old cane (Fields 20-B and 9A). It was planted butt to butt, requiring 80 bags per acre. Germination was not good, 10 bags per acre of replant being needed to make a solid stand. Strikebreakers (Hawaiian women and Boy Scouts) did the planting.

"(3) Irrigation rounds averaged 13.55 days from August 1st to December 1st. Heavy winter rains made irrigation unnecessary until March. From then until the following November, the rounds averaged 20.1 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

" 'Third season' irrigation consisted of one round completed on March 16th, or 74 days before the field was harvested.

"The following laboratory record gives the juice analysis:

Tons cane per ton sugar	7.75
Percent sucrose	14.16
Brix	19.52
Polarization	16.98
Purity	86.99

"The cane could have been ripened further.

"(4) The field was not fertilized until December, the delay being due to the labor situation following the strike. One thousand and forty-seven pounds per acre of 'F' fertilizer were applied, giving 105 pounds of nitrogen per acre and 31 pounds of K_2O and 31 pounds of P_2O_5. Two doses of 500 pounds per acre of nitrate of soda were applied in the irrigation water, finishing on March 30th and June 14th, 1921.

"(5) There was a good growth of weeds to contend with, the charges being $3.00 per acre for this item.

"(6) Harvesting commenced on June 7th and finished on June 19th, 1922, making the cane approximately 23 months old.

Tons sugar per acre per month	.677
Tons sugar per acre per crop	15.58
Tons cane per acre per crop	121.08

Field 16-C (72.50 Acres), 1922 Crop, Plant Cane:

"(1) Before planting Field 16-C was harvested April 14th to 22nd, 1920.

"(2) The field was planted July 25th to August 3rd. The seed was unselected body seed from 12-months old cane (Fields 20-B and 9A). It was planted butt to butt and required 69 bags per acre. Replanting too 3½ bags per acre. Planting was done by strikebreakers, who were Hawaiian women and Boy Scouts.

"(3) Irrigation rounds averaged 13.55 days from August 19th to December 22nd, 1920. Heavy winter rains made irrigation unnecessary until March. From then until the following November, the rounds averaged 20.1 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

'Third season' irrigation was completed on March 11th. The field had two rounds and 'Dryspotting.' Irrigation was suspended 60 days before harvesting.

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. One thousand and twenty-four pounds per acre of "F" fertilizer were applied, giving 113 pounds of nitrogen per acre, 31 pounds of P_2O_5 and 30 pounds K_2O. Two doses of nitrate of soda, 496 pounds per acre each, were applied in the irrigaton water, finishing on March 21st and June 19th. The field thus received a total of 256 pounds of nitrogen.

"The laboratory record gives the following juice analysis:

Tons cane per ton sugar	7.86
Percent sucrose	13.88
Brix	19.13
Polarization	16.69
Purity	87.25

"The cane could have been ripened further except a 12-acre portion of the field on shallow coral soil.

"(5) There was a vigorous weed growth, especially in the coral area; the charges were $3.00 per acre for this item.

"(6) The harvesting commenced on May 26th and finished June 8th, 1922, making the cane about 23 months old.

Tons sugar per acre per month	.673
Tons sugar per acre per crop..........	15.14
Tons cane per acre per crop	119.00

Field 1-E (58.80 Acres), 1922 Crop, Plant Cane:

"(1) Before planting Field 1-E was harvested May 20th to May 27th, 1920.

"(2) The field was planted August 8th to 17th, 1920. The seed was unselected body seed from 12-months old cane in Field 9-B. It was planted butt to butt and required 71 bags per acre. Germination was poor, as it took 14 bags per acre to replant it. Field was planted by Boy Scouts.

"(3) Irrigation rounds averaged 13.5 days from September 1 to November 9. Winter rains made irrigation unnecessary from December 22nd to February 17th. From then until the end of October, the rounds averaged 23 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

'Third season' irrigation was completed on April 15th, 1922, consisting of nearly one complete round, or 66 days prior to harvesting.

"The laboratory record gives the following juice analysis:

Tons cane per tons sugar	7.05
Percent sucrose	15.12
Brix	21.12
Polarization	18.37
Purity	86.98

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. One thousand and six pounds per acre of "F" fertilizer were applied December 6th, 1920, equivalent to 101 pounds of nitrogen, 30 pounds of P_2O_5 and 30 pounds of K_2O. Two doses of nitrate of soda, of 500 pounds each, were applied in the irrigation water, being finished on March 25th and June 23rd. The field thus received a total of 251 pounds of nitrogen per acre.

"(5) There was weed growth, the charges for hoeing being $3.53 per acre.

"(6) Harvesting commenced on June 21st and finished June 7th, 1922, the cane being not quite 23 months old.

Tons sugar per acre per month	.67
Tons sugar per acre per crop	15.51
Tons cane per acre per crop	109.34

Potash in the Hilo District.

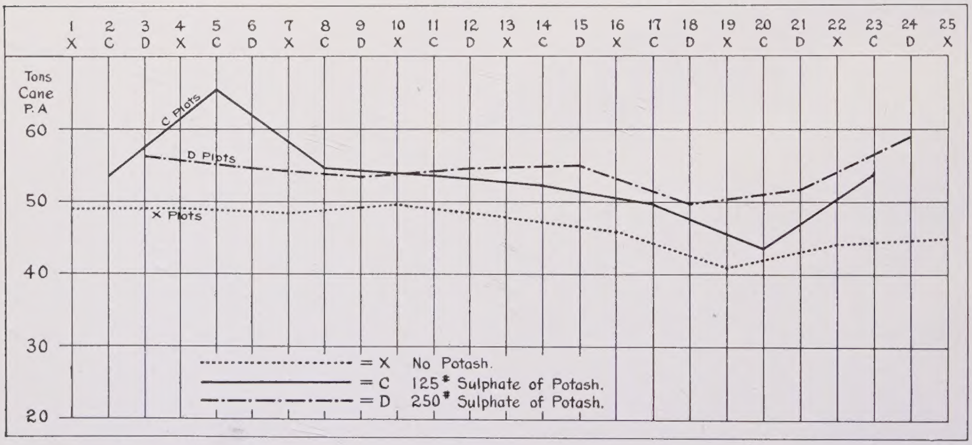
By J. A. Verret.

Pepeekeo Experiment No. 6, 1922 Crop.
Onomea Experiment No. 11, 1922 Crop.

We have recently harvested two experiments in the Hilo district, from both of which we obtained distinct gains from the use of potash.

Experiment No. 6 at Pepeekeo compared 125 and 250 pounds per acre of sulphate of potash with no potash. The cane was Yellow Caledonia, planted August 6, 1920, and harvested May 1, 1922. All plots received equal amounts of nitrogen from 750 pounds of sulphate of ammonia per acre. This was applied in three equal doses, in October and November, 1920, and March, 1921. The potash was applied in late August, 1920.

AMOUNT OF POTASH
Pepeekeo Sugar Co. Exp. 6, 1922 Crop
Field 2 A.



The results obtained at harvest are tabulated as follows:

Treatment	Tons Cane per Acre
No potash	46.8
125 lbs. sulphate of potash	51.7
250 lbs. sulphate of potash	54.4

Results of a similar nature were obtained in several experiments at Onomea.

A ton of cane, as it goes to the mill, removes from 2 to 3 pounds of potash (K_2O) from the soil. A part of this is returned to the fields in the mud press cake and mill ashes.

We see from this that unless we wish to further deplete the already low potash in the soils of the Hilo district, we should add at least 120 pounds of K_2O per acre per crop. If all mud press cake and mill ashes are returned the above amount should take care of a 40-ton crop without too great a strain on the soil.

In fields averaging yields much above this it would be advisable to use larger amounts of potash.

In experiment No. 11 at Onomea we compared equal amounts of K_2O from sulphate of potash, muriate of potash, and molasses ash.

The cane was Yellow Caledonia, planted May 1, 1920, and harvested June, 1922. The potash was applied May 14, 1920. All subsequent fertilizations were uniform to all plots. On July 13, 1920, 300 pounds of nitrate of soda per acre were applied. On September 21, 1920, and March 22, 1921, applications of ammonium sulphate were made at the rate of 300 pounds per acre.

The results obtained at harvest are given below:

Treatment	Pounds K_2O	Tons Cane per Acre
Sulphate of potash	75	40.3
No potash	...	33.1
Muriate of potash	75	39.8
No potash	...	34.3
Molasses ash	75	38.5
No potash	...	35.4

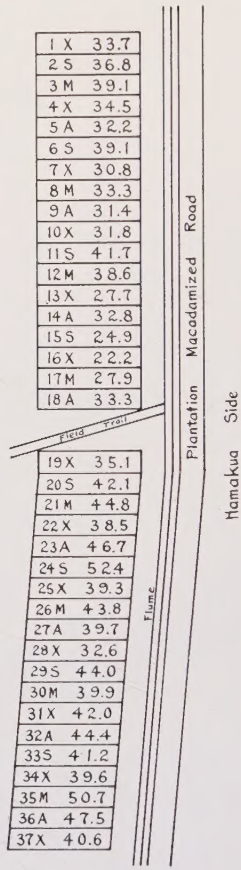
The above results are slightly in favor of sulphate of potash, and although final conclusions cannot be drawn on the results of one experiment, at about equal cost per unit of K_2O, the sulphate should be preferred. The sulphate should be preferred for other reasons also. On irrigated plantations large amounts of chlorides are being added to the soils in the pump waters. We should not increase these amounts if we can help it.

In the rainy districts the lime content of the soils has a tendency to be low. When using muriate of potash the chlorine in the muriate would tend to combine with lime, forming calcium chloride, which is rather soluble in water. This would cause a rather rapid loss of lime. Sulphate of potash, on the other hand, would cause the formation of calcium sulphate, which is only very slowly soluble in water.

Forms Of Potash
Onomea Sugar Co. Exp. 11, 1922 Crop
Field 95.

Summary of Results

Plots	Treatment	Tons Cane Per Acre
S	75* K_2O from Sulphate of Potash.	40.3
X	No Potash.	33.1
M	75* K_2O from Muriate of Potash.	39.8
X	No Potash.	34.3
A	75* K_2O from Molasses Ash.	38.5
X	No Potash.	35.4



Details of Experiments.

ONOMEA EXPERIMENT 11,—1922 CROP.

Potash: (1) *Value of:*
(2) *Kind to apply:*

Object:

To determine the value of applying potash, and to compare the following forms:

Sulphate of Potash (46.96% K_2O).
Muriate of Potash (54.24% K_2O).
Molasses Ash (33.92% K_2O).

Location:

Onomea Sugar Co., field 95 (along Hilo side of macadam road, running through Paukaa Section.

Crop:

Yellow Caledonia, plant cane, (planted May 1, 1920).

Layout:

Number of plots = 37.

Size of plots = 1/10 acre, consisting of 6 lines, each line 5.5 feet wide and 132.0 feet long.

Plan:

Fertilization.

Plots	Number of Plots	May 15, 1920		Total K_2O
		Kinds of Potash	Pounds Potash	
X	13	None	.....	...
S	8	Sulphate of potash	159.7	75 lbs.
M	8	Muriate of potash	138.3	75 "
A	8	Molasses ash	221.1	75 "

Fertilization:

Uniform according to the following schedule:

Pounds of Nitrate of Soda per Acre.

	July 15, 1920	Sept. 21, 1920	March 15, 1921	Total Nitrogen
All plots ..	300	400	300	155

Pepeekeo Sugar Co. Experiment No. 6, (1922 Crop).

Object:

To determine the amount of potash to apply.

Crop:

Yellow Caledonia, planted August 6, 1920; harvested June, 1922.

Location:

Pepeekeo Sugar Co., field 2A.

Layout:

Twenty-five plots, each 1/10 acre, consisting of 6 lines, 6.17 feet wide, 117.7 feet long.

Plan:

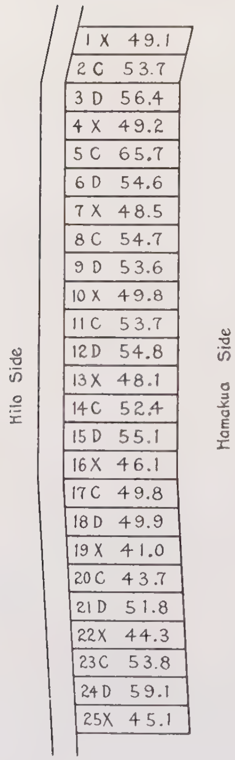
Fertilization — Pounds per Acre.

Plots	Number of Plots	Aug., 1920	Oct., 1920	Nov., 1920	March, 1921
		Sulph. Potash	Sulph. Ammo.	Sulph. Ammo.	Sulph. Ammo.
X	9	...	250 lbs.	250 lbs.	250 lbs.
C	8	125 lbs.	250 "	250 "	250 "
D	8	250 "	250 "	250 "	250 "

Amount Of Potash

Pepeekeo Sugar Co. Exp. 6, 1922 Crop

Field 2 A.



Summary of Results

Plot	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q. R.	Sugar
X	9	No Potash.	46.8	7.88	5.94
C	8	125# Sulphate of Potash.	51.7	7.82	6.61
D	8	250# Sulphate of Potash.	54.4	8.28	6.57

Notwithstanding these points in favor of the sulphate over the chloride, the fact remains that in practice the chloride has found a wide field of usefulness in the fertilizer markets of the world and is perhaps more extensively employed than sulphate.

Field trials generally, drawing from mainland and European results, show for most crops little or no difference between sulphate and chloride of potash. A few crops, however, show much better results with sulphate, the chloride apparently having a toxic effect.

As to whether sugar cane is to be classed among the plants that make better response to sulphates than chlorides is a matter to be established by further tests.

Molasses ash usually contains chlorides to sulphates in the proportion of about two to one and small quantities of carbonate of potash are also present.

Flume System of Irrigating Sugar Cane.

By H. W. Baldwin.

PREPARING: This system may be used on any field regardless of contour, as it is adapted to both hilly and moderately level land.

After the field has been well harrowed, the flume lines which have been previously worked out on the contour map, are staked out in the field. These flume lines are laid out in such a way that the furrows can be run from either side in "herring bone style," with rows between 150 feet and 200 feet, more or less, in length. These rows should have a fall of from one to three feet per 100 feet preferably, but may have more or less as required. They may be straight or curved according to the contour of the field.

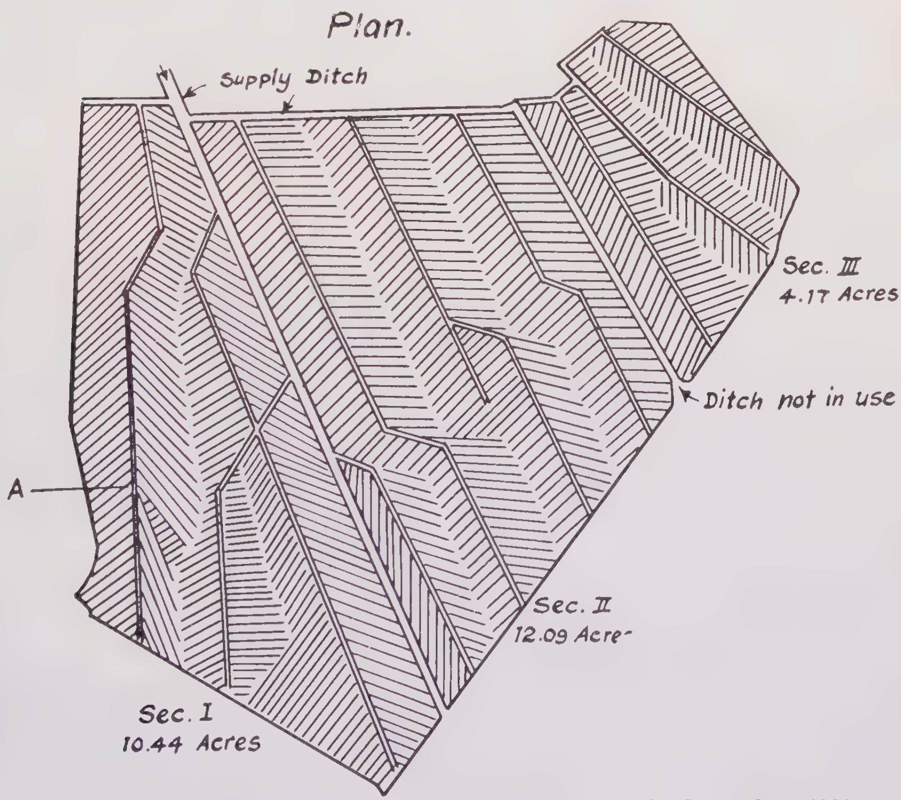


Fig. 1. Map of 27-acre field planted to flume system in September, 1921.

FURROWING: We are trying two methods of spacing and furrows. In one section the furrows are spaced 1¾ feet apart and in the other 2 feet apart, as shown in the sectional view, Fig. 2.

The cane is planted in two adjoining furrows, then a furrow is left for water and the next two furrows are planted and another furrow is left for water. etc. Thus the water furrows are spaced 5¼ feet apart in Section 1, and 6 feet

apart in Section 2, with two rows of cane in between. This results in 16,620 linear feet and 14,520 linear feet of cane rows respectively per acre, or 98% more cane per acre in one case and 73% in the other, than by the regular system.

The direction of the rows is laid out by the surveyors, a line of cane tops marking the lines at intervals of about 50 feet.

The furrows are made with a furrowing sled having 8″ x 8″ runners set on edge. On the 27-acre plot which we are now raising by this system, a small two-runner furrowing sled was used. (Fig. 3.) This was drawn by a pair of horses, the driver riding on the sled.

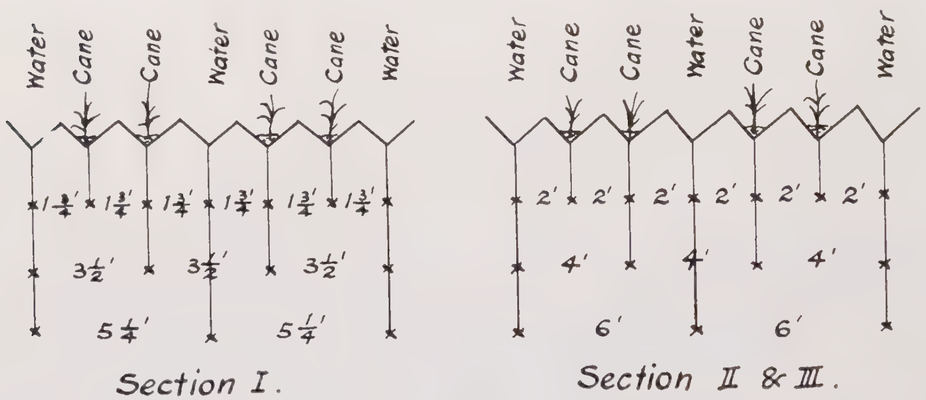


Fig. 2. Showing spacing of furrows.

COVERING: After the seed was dropped a small furrow (Fig. 4) was made with the hoe between the adjoining cane rows, covering the seed at the same time. This small furrow was used for the first few irrigations or until the roots were established, after which the water was supplied in the regular water furrows.

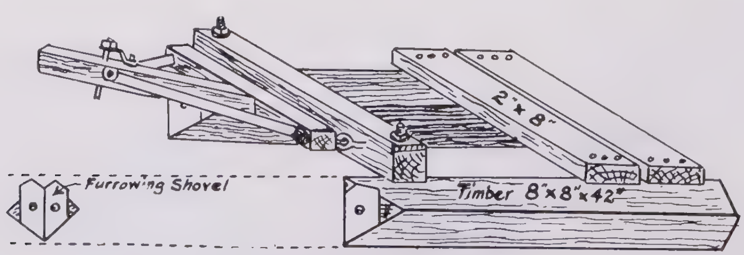


Fig. 3. Furrowing sled.

COMBINED FURROWING, PLANTING AND COVERING SLED: This year we expect to use a two-row furrowing sled equipped with a seed dropping apparatus which will enable us to furrow, plant and cover all in one operation.

FLUMES: The flumes are laid in the field after the furrowing is completed, as otherwise they would interfere with the movements of the furrowing sled.

The flumes are made of one-inch redwood, surfaced on the inside. It is economy to use surfaced lumber as it reduces friction and gives greater capacity. The economical size of flume is one in which the width is about double the depth.

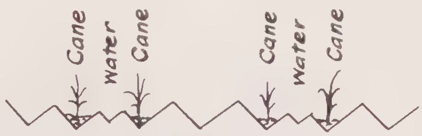


Fig. 4. Showing furrows used for the first irrigation.

The maximum size of flume to start with is 6 inches deep by 10 inches wide. The flumes should be placed in the ground slightly in order that the tops will be about level with the ground surface, so that the horses can cross readily when cultivating.

Two-inch holes are bored in the sides of the flume opposite the water furrows These holes are fitted with galvanized iron gates, Fig. 6. We have been placing these gates on the inside, sliding upward, but they are often bent by the horses' feet in crossing the flume, so hereafter we plan to place them on the outside to slide horizontally, Fig. 7.

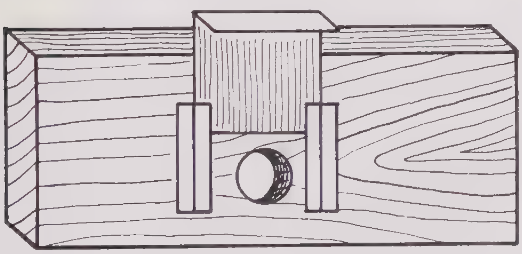


Fig. 6. Galvanized iron gate attached to scrap lumber.

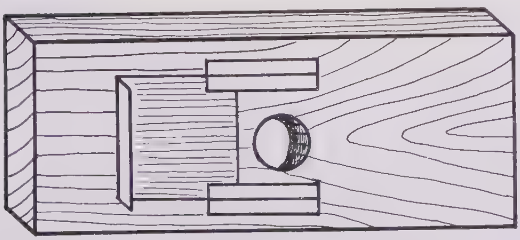


Fig. 7. Galvanized iron gate sliding horizontally, to be adopted.

DISCHARGE PER OUTLET: With the holes wide open and a depth of three inches of water in the flume, each hole will discharge about .044 cubic feet per second. After the first two or three irrigations the water flows much faster in the row than at first and the discharge per hole can be gradually lessened. By the fifth or sixth round the desirable flow is about .0146 sec. feet.

A 6″ x 10″ flume will carry approximately 2.5 sec. feet, depending on the grade. This is sufficient for about 45 rows for the first water, or 170 rows for fifth or sixth water, or for 700 linear feet of flume, as there are about six holes per 25 feet of flume.

Each 25 foot section of flume will discharge through its six outlets a total of about .0876 sec. feet after the sixth round, and each succeeding section will carry .0876 sec. feet of water less than the preceding one, and the flumes should be designed accordingly, so that they will gradually taper down and be full at all points. If the flumes are not full it is necessary to place small sticks, about an inch square and a little longer than the width of the flume, diagonally across the floor of the flume to back the water up by the outlet so that a sufficient flow will issue.

At the end of the 700 foot section of flume a level ditch should be brought in to feed the next 700 foot section, etc. This level ditch will cross some of the cane rows and the portion of the rows below the ditch should be irrigated from the ditch by means of small pieces of scrap 1″ x 6″ lumber about eight inches long inserted in the ditch bank in such a way that water will flow through holes bored in the board. These holes should have gates attached similar to the ones in the flumes. Lath tubes can be used for the same purpose, but should have galvanized iron gates to control the flow. (Fig. 8.) Short level ditches can often be used in this way to save flumes where the contour of the land is favorable.

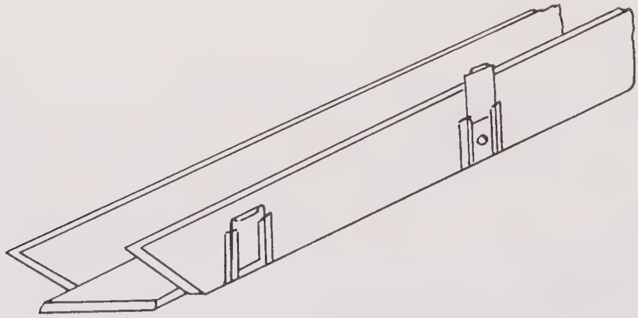


Fig. 5. Showing construction of flumes.

IRRIGATION: The first two or three irrigations are applied in the small furrow in the narrow space between the cane rows. (Fig. 4.) The water reaches half way down the row in a comparatively short time, but has now become so diminished that it progresses very slowly. It was found to be economy to shut the water off from the row about this time and not attempt to water the last half of the row until the following day, by which time the ground has settled in the first half of the row and become less pervious than it was the day before. When the stream now reaches the middle of the row again, which it does very quickly, it is much larger than it was the previous day and the last half of the row can be watered in much less time than would have been required the day before.

After the first 45 rows or so have been irrigated the small gates are closed and the next 45 rows are irrigated, etc.

With each succeeding irrigation the water will run faster and the size of the stream in each row will be gradually diminished until there will be sufficient water to supply all the holes in the 700 foot section of flume at one time. The gates should now be adjusted so that the water will reach the ends of the rows at about the same time. After this the gates will not have to be changed.

The first irrigation requires from six to seven inches of water per acre, but subsequent irrigations take less and less until in the fifth or sixth round it is found that with each row receiving .0146 sec. feet only one acre inch per acre will be applied per hour, so that it is necessary to allow the water to flow for several hours in order to give a sufficient application.

We are irrigating every week, as we believe that a light application of two or three inches per week will give better results than four or six inches every two weeks.

The fact that water running in a long row for several hours does not result in a waste of water seems rather unbelievable to some; in fact, it seems inconsistent with the writer's former experiments given in the report of the "Committee on Irrigation" at the annual Planters' meeting of 1920. But it is really not as inconsistent as it seems, for in the former case we were dealing with large flows of water running in level furrows which have been undisturbed by cultivation and have been baked in the sun for from fifteen to twenty days after each irrigation.

We are now dealing with entirely different conditions. Here we have furrows with a fall of from two to three feet per 100 feet. The ground is pulverized by frequent cultivation which forms a mulch and conserves moisture. With a weekly application of water followed by cultivation the optimum moisture content is practically maintained and the ground does not become baked. The constant stirring of the soil by the cultivator breaks up the soil into small particles which are carried by the water into the pores below, closing them and effectively

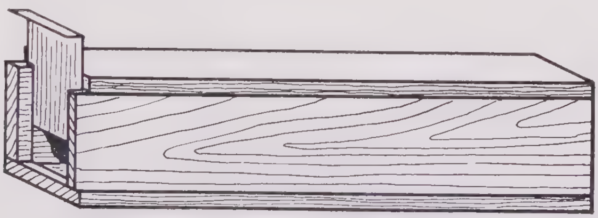
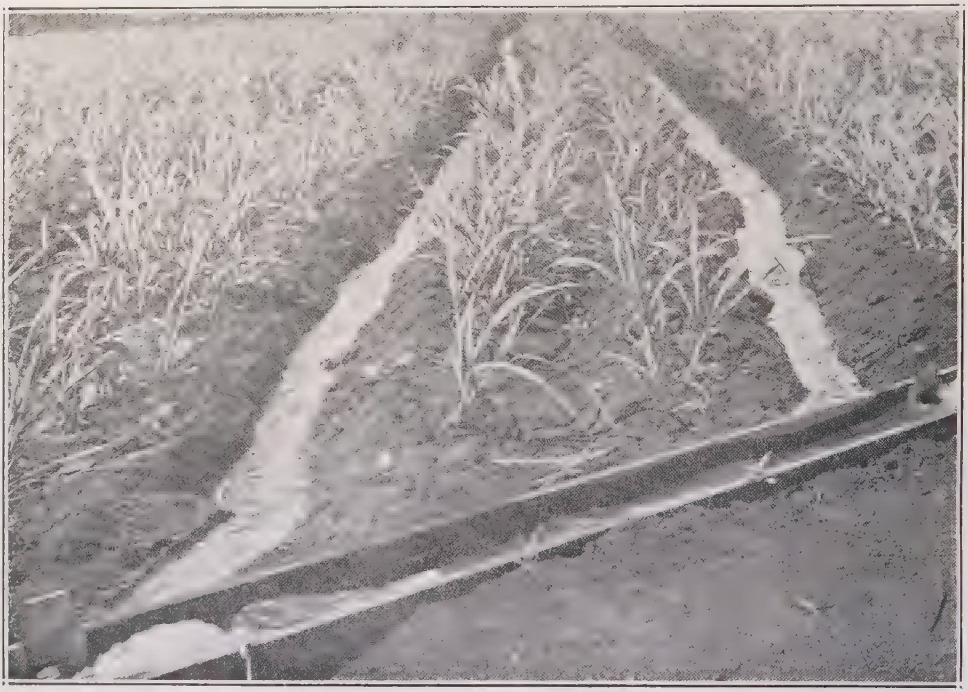


Fig. 8. Lath tube with galvanized iron gate.

preventing excessive water losses by deep percolation. The water flowing down the rows as a thin sheet penetrates downward as well as laterally, practically by capillary action. The longer the surface is kept saturated the longer this capillary action will continue. Water spreads farther by capillary action in a fine-textured, compact soil than in a loose, coarse soil, but requires a longer time, whereas, in the latter case it spreads faster but not so far. It is believed that a much greater lateral penetration is obtained by allowing a small stream to run for a long time than would result with a large stream running for a short time.

The action of the fine soil particles in retarding deep percolation losses is somewhat analogous to the action of slow sand filters such as those of the Hawaiian Commercial and Sugar Company, in which water is filtered through beds

of sand. After a few days the interstices of the sand surface become so stopped by silt that even with several feet head the water penetrates so slowly that several inches of sand have to be removed from the surface of the sand beds at frequent intervals.



A field of young cane, showing the double row method of planting under the flume system of irrigation.

ACRES IRRIGATED PER MAN PER DAY: On the 27 acre field the flumes are all of one size, namely, 4″ x 8″. No level ditches were used to feed the flumes except at the beginning, consequently the flume carries only enough water to supply about half the holes at a time. When these are finished the gates have to be closed so that the lower part of the flume will be supplied. At the next irrigation the gates have to be opened again. This involves considerable labor and prevents the nice adjustment possible with the improved system which will do away with the opening and closing of the gates after they are well adjusted. One man now irrigates the 27 acres in three days.

With the improved system properly installed as outlined above, and the gates well adjusted, the irrigator will simply turn the proper amount of water into the flumes and allow it to run for several hours. The water will then flow into all of the rows automatically and the attendant will have only to patrol the flumes to see that none of the outlets are obstructed and to inspect the ends of the rows to be sure that the water has reached the ends and had ample time to

spread laterally before the water is turned off. Thus it should be possible for one man to irrigate a whole field in a day if there is a sufficient volume of water available.

First ratoons of D 1135, grown under the flume system of irrigation.

CULTIVATION: After the roots are established the water is applied in the regular water furrows between the double rows of cane instead of in the furrow between the single rows of cane. The first irrigation in the water furrow will require a great deal of water but the subsequent irrigations will require less. After the second or third round in the water furrows, cultivation is started. About two days after the irrigation a one-horse Planet Jr. cultivator is used, equipped with side hoes and irrigation shovel in the rear. This is run in the water furrow, the horse stepping over the flumes while the cultivator is lifted over. The cultivator destroys the weeds on two-thirds of the surface area and forms a soil mulch which conserves moisture, and the furrow is left ready for the next irrigation. The only hand-weeding required is on the narrow strip between the cane rows. Only two or three hand-weedings are required, as the cane shades in quickly on this narrow strip so that the weeds do not grow.

The cultivator is used for five or six months or until the cane becomes too large to permit the cultivator to pass between the rows. As the cane grows the side hoes are removed and a larger shovel with side wings used which throws more dirt onto the cane.

YIELD: From the small plot of D 1135 cane raised by this system last year we obtained 92.7 tons of cane per acre which yielded 10.35 tons of sugar per acre. Single rows of cane raised by the same system gave 78.3 tons of cane and 8.32 tons of sugar per acre.

WATER APPLIED: The water applied to this crop was as follows:

Round No.	Inches per Acre.
1	6.20
2	6.12
3	4.60
4	4.31
5	4.06
6	2.18
7	1.62
8	2.24
9	1.06
10	1.78
11	2.13
12	1.66
13	1.46
14	1.85
15	1.78
16	1.58
17	2.18
18	2.13
19	1.42
20	1.53
21	1.14
22	1.53
23	1.64
24	1.59
25	1.53
26	2.25
27	1.85
28	1.38
Total irrigation water	64.80
Rainfall	27.20
TOTAL WATER APPLIED	92.00 ACRE INCHES

Thus 1,002 pounds of water were required to produce one pound of sugar.

In this experiment the aim was to see how much sugar could be raised with a minimum amount of water. On the 27 acre plot this year we are giving heavier applications of water with the expectation of increasing the yield.

DUTY OF WATER IN HAWAII: The following table, taken from the U. S. Department of Agriculture Bulletin No. 90, by Walter Maxwell, gives comparative figures on the "Duty of Water in the Hawaiian Islands." To this table have been added the figures given above as well as like data reported in the April, 1922, *Planters' Record,* showing results obtained at Waipio and elsewhere.

The small streams of water are issuing from the right-hand side of the flume. One of them can be seen in the immediate foreground of this picture.

This field of H 109 cane was also handled by the new irrigation system.

DUTY OF WATER IN HAWAIIAN ISLANDS.

	Water Applied per Acre per Crop		Yield of Sugar per Acre	Water Required to Produce One Pound of Sugar
	Depth	Quantity		
According to Schuyler & Allardt:	*Inches*	*Gallons*	*Pounds*	*Pounds*
Spreckelsville (1)	262.00	7,114,348	11,100	5,345
Spreckelsville (2)	216.00	5,865,264	11,100	4,407
Hamakuapoko	230.20	6,250,850	11,300	4,613
At the Experiment Station:				
First crop (1897–98)	94.51	2,567,682	24,755	865
Second crop (1898–99)	103.01	2,797,133	27,133	859
April (1922) Record (1921) ..	187	....	19,700	2,140
Hamakuapoko:				
Field 8 (1920–21)	216.96	5,892,518	10,100	4,860
Field 3 (1921–22)	92.00	2,490,000	20,700	1,002
Average given in Planters' Record of April, 1922, for Oahu, Maui and Kauai..				3,898

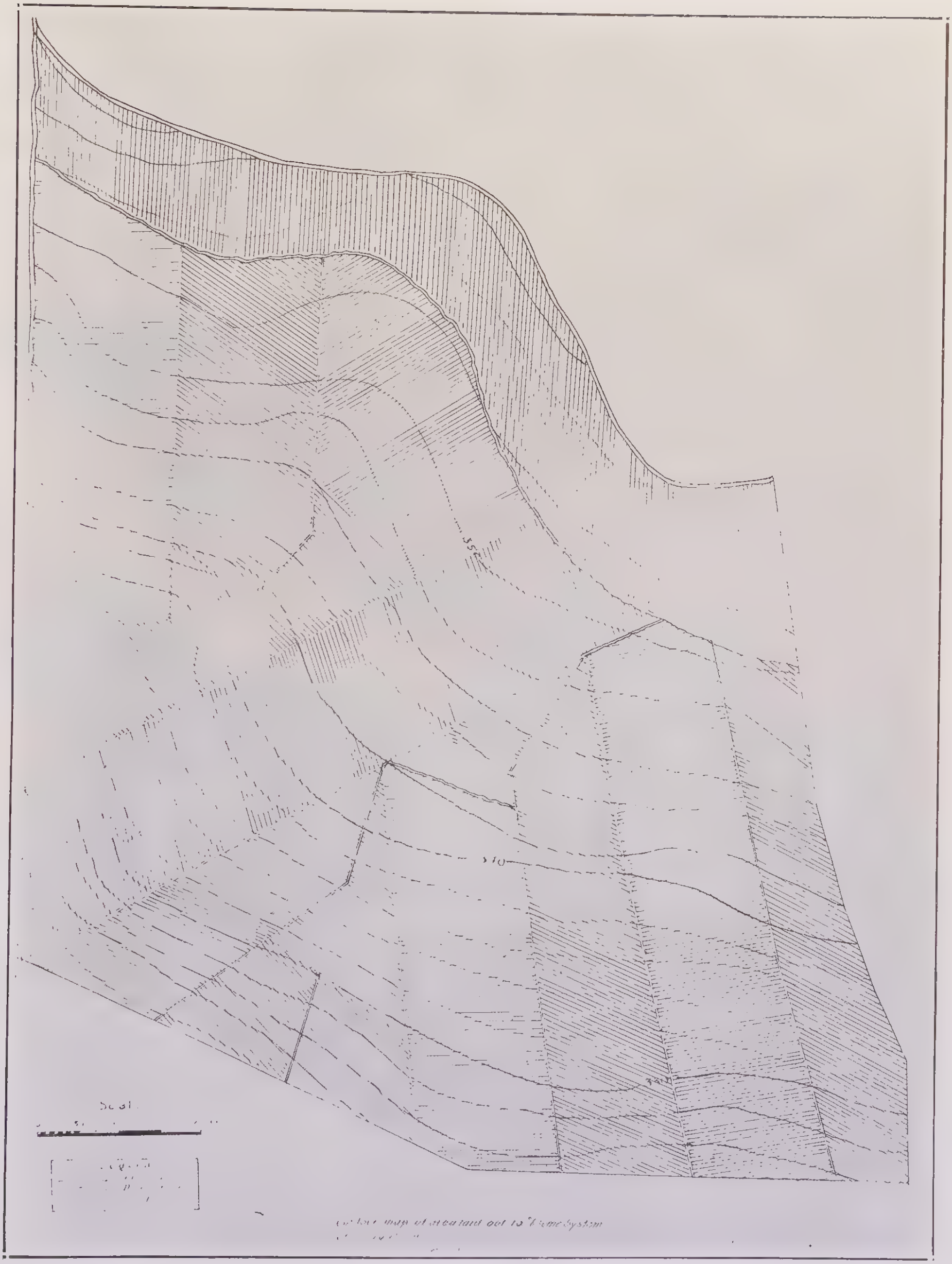


Fig. 9. Contour map of a cane field laid out under the flume system of irrigation.

COST OF FLUME SYSTEM: The costs given below are for the 27 acre plot. By improved methods we expect to reduce these costs materially on the field to be planted this year.

The irrigation costs include the cost to date plus an estimated cost of 28 more irrigations at $0.15 per acre per round.

	Cost per Acre
Furrowing	$ 2.50
Preparing and ditching	2.75
Planting	6.62
Irrigation	10.94
Weeding	16.33
Cultivating (includes horses at $0.50 per day)	6.89
Flumes ($27.40 per acre, distributed to three crops)	9.13
TOTAL ESTIMATED COST FOR THE CROP *	$ 55.16

Detailed Cost of Flumes:

Lumber	$544.60
Galvanized iron	36.00
Labor complete in place	170.33
Total	$751.33
Cost per lineal foot of flume	$ .0975
Cost per acre	27.40

By carefully laying out the system on a two-foot contour map of the field we are to plant this year (Fig. 9) we have been able to reduce the amount of flume necessary to 170 feet per acre. This should cost about $17.00 per acre with the same price for lumber as last year, or a cost of $5.66 per acre if the flume cost is distributed to three crops.

* Cost of fertilizer and water omitted.

Liming.

By J. A. Verret.

Niulii Mill & Plantation Co., Experiment 1,—1922 *Crop.*

Pepeekeo Sugar Co., Experiment 5,—1922 *Crop.*

We have recently harvested two experiments on Hawaii having to do with liming. One was in the Hilo district at Pepeekeo and the other in the Kohala at Niulii. The cane in both cases was Yellow Caledonia.

The soil in the experimental area at Pepeekeo was rather highly acid, requiring two tons of quicklime to neutralize the upper ten inches of soil. The Niulii soil was not sampled at the time the experiment was put in, but other soil samples from this plantation show about twice as much available lime as do the soils in the Hilo district.

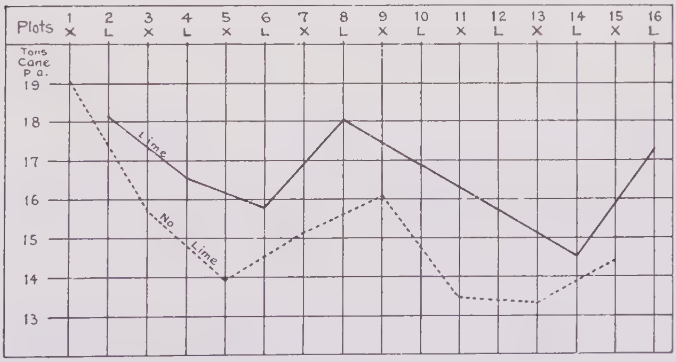
In both cases all plots received uniform fertilization, corresponding to that given to the rest of the field by the plantation.

The amounts of lime used and the results obtained are given in the two following tables:

Lime Experiment

Niulii Mill & Plantation Co. Exp. 1, 1922 Crop

Field 28. Makapala.



NIULII EXPERIMENT 1—LIME.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Two tons Waianae lime	16.7	8.65	1.92
No lime	15.2	8.43	1.80

PEPEEKEO EXPERIMENT 5 — LIME.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Four tons lime per acre	50.1	7.70	6.51
Two tons lime per acre	49.4	7.74	6.39
No lime	51.7	7.94	6.52

The rather low yields at Niulii were due to two bad years in succession when the cane suffered severely from drought. Dry weather made it necessary to replant this field twice.

The returns at Niulii, although small, were consistently in favor of lime — that is, all the lime plots were a little bit better than the adjoining no lime plots. But although these gains are consistent, they are too small to be profitable unless the beneficial effects of the liming are continued for several crops.

Under good weather conditions with bigger yields, the gains from liming might have been larger and economically profitable.

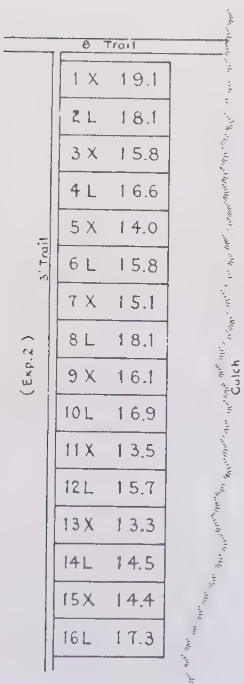
We plan to continue this test for several crops, without further additions of lime, to determine how long the original lime is effective and to note the total sugar gained from this amount of lime.

The results obtained at Pepeekeo did not follow those obtained at Niulii, in that there were no increased yields from the lime plots.

LIME EXPERIMENT

Niulii Mill & Plantation Co. Exp. 1, 1922 Crop

Field 28. Makapala.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
X	8	No Lime	15.2	8.43	1.80
L	8	2 Tons of Waianae Lime	16.7	8.65	1.92

As a whole, our lime experiments to date have given negative rather than positive results. Even in the few experiments which show gains, these gains have generally been too small to be profitable. Plantations which do not fertilize heavily would get much higher returns for the money spent by buying nitrogen rather than lime.

Before any extensive liming operations are started, they should be preceded by a thorough investigation of the returns to be expected.

Details of Experiments.

NIULII MILL AND PLANTATION CO., EXPERIMENT 1, — 1922 CROP.

Object:

To determine the value of applying lime in the Kohala district.

Location:

Niulii Mill and Plantation Co., field 28, Makapala.

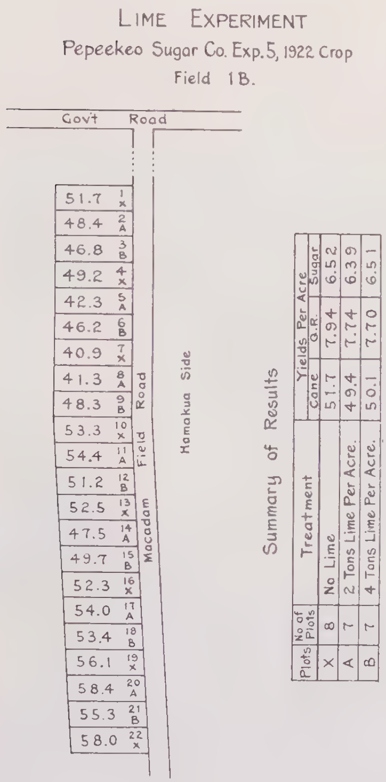
Crop:

Yellow Caledonia, plant cane (August 10, 1920).

Layout:

Number of plots = 16.

Size of plots = 1/20th acre, consisting of 6 lines, each line 4.7 feet wide and 78.55 feet long.



Plan:

Odd plots (X) = no lime.

Even plots (L) = 2 tons of lime per acre.

Fertilization:

Uniform to all plots according to the following schedule:

January 28, 1921 — 500 lbs. of High Grade per acre.

June, 1921 — 250 lbs. of Nitrate of Soda per acre.

High Grade = 12% N, 6% P_2O_5, 1% K_2O.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.

Experiment laid out by H. L. Denison.

Experiment harvested by W. C. Jennings.

PEPEEKEO EXPERIMENT 5, — 1922 CROP.

Object:

To determine the value of lime on acid soil.

Location:

Pepeekeo Sugar Company, field B.

Crop:

Yellow Caledonia, plant cane.

Layout:

Number of plots = 22.

Size of plots = 1/10 acre, consisting of 6 lines, each 5.75 feet wide and 126.84 feet long.

Plan:

Plots	Number of Plots	Plot Numbers	Treatment
X	8	1, 4, 7, 10, 13, 16, 19, 22	No lime
A	7	2, 5, 8, 11, 14, 17, 20 ...	2 tons per acre Waianae lime
B	7	3, 6, 9, 12, 15, 18, 21 ...	4 tons per acre Waianae lime

Fertilization:

Fertilization in Pounds per Acre.

Plots	September 1, 1920	November 1, 1920
All	375 lbs. B-7	375 lbs. B-7

B-7 = 11% N, 6% P_2O_5, 6% K_2O.

Soil Analysis: Colorimetric method — lime requirement to bring to immediate neutrality — 2 tons Waianae lime per acre. Recommended application to maintain at neutral point — 3 to 4 tons Waianae lime per acre.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.
Experiment harvested by H. K. Stender.

The Maui Progenies.

By W. W. G. Moir and E. L. Caum.

The briefly summarized data presented below were obtained from experiments planned and laid out by the writers, and carried on by them with the cooperation of the Maui Agricultural Company and the Wailuku Sugar Company. The work to date divides naturally into four parts, corresponding to the four years 1919 to 1922, but for the sake of convenience the progress on the individual experiments is detailed from the beginning to the present time, instead of each year's work being dealt with as a unit. In the beginning, the different experiments were numbered, each number being preceded by the letter S, an abbreviation of Selection. Later this system was discontinued, the progenies from the various experiments being combined into two groups, corresponding to the two plantations, and each group numbered consecutively.

Experiments S 1 to S 5 were planted in the Seedling Nursery, Hamakuapoko Section, Maui Agricultural Company; S 6 in Field 96, and S 7 to S 16 in Field 95, Wailuku Sugar Company.

EXPERIMENT S 1. Early in 1919, H. D. Sloggett, then in charge of the Hamakuapoko Section of the Maui Agricultural Company, cut a number of eyes of H 109 cane, choosing large eyes from big sticks. These eyes were germinated in pots made from shingles, and on May 12, fifty were set out in Field 4, spaced about a foot apart in the row. These plants were not given any special treatment, being handled under the normal plantation method.

On May 28, 1920, the forty stools remaining from Mr. Sloggett's original planting were cut, data being taken on the number of sticks, suckers and shoots per stool, relative size, and vigor of growth. The seed from these stools was planted end to end, with an 18-inch space between progenies. In all cases every stick of each stool was cut for seed, the entire stool being used for this purpose. Observations made during the year showed great variation among the progenies of the several stools, and in 1921, after one year's growth, the difference in tonnage of cane in some cases was over 200%. A survey was made, and stools selected from eighteen of these progenies for planting in the progeny-test area at Hamakuapoko. Data were taken on the number of sticks per stool, relative size of sticks, and the color and growth types.[1] The forty original progenies were ratooned for further study. The eighteen selected stools were given consecutive numbers in the new progeny planting mentioned above, and the later work on this planting will be dealt with further on.

[1] H 109: A Study in Variation. Haw. Pl. Rec. XXV, pp. 269–281. (Dec., 1921.)

EXPERIMENT S 2. On June 2, 1920, ten stools of H 109, each very uniform for size of stick and with a minimum of eight sticks each, were cut in Field 4, M. A. Co. The standard used in selecting these stools was exceedingly high for this field, which is one of the oldest on the plantation, and is heavily infested with nut-grass. Data were taken on the number and relative

Fig. 1. A first ratoon stool from a single eye, at one year of age.

length and diameter of sticks, and position of the stools in the field, as regards ditches, water-courses, etc. Density readings of juice samples from each stick were made with the refractometer. Each stick of each stool was then cut for seed and planted. The seed-pieces from each progeny were sorted out according to the number of eyes on each, and those of a like number of eyes planted together. These seed-pieces were spaced about ten inches apart in the row, with a larger space separating the series of four-eye cuttings, for instance, from the three-eye series. A space of two and a half feet separated progenies.

In 1921 a survey was made and differences noted between progenies as regards type of growth and uniformity of stand, as well as in the comparative value of the progenies as a whole. Stools were selected from six of these for planting in the progeny test area, the other four being discontinued. They were all

good stools from good progenies, differing in this respect from those chosen from S 1, which in some cases were good stools from mediocre progenies. Spacing the seed seemed to have a tendency to induce stooling. As a general rule only two or at most three eyes per seed piece germinated, indicating that there is no advantage in the use of seed pieces with a greater number of eyes. Correlated with this there is a disadvantage in the unnecessary amount of cane planted. These progenies also were allowed to ratoon.

EXPERIMENT S 3. On June 3, 1920, twelve sticks of plant H 109 and six of ratoon Lahaina were cut, data being taken on the degree of uniformity of the stool and the absolute size of the stick. These sticks were then cut into single-eye seed-pieces, and each eye planted, the pieces being spaced eight inches apart, and arranged in the order of their occurrence on the stick.

On the 1921 survey it was noted that only twenty eyes of the three hundred and eighty-six planted failed to germinate, a failure of less than 5%. These twenty failures were scattered throughout the length of the sticks, being grouped neither near the butts nor the tops. In only two cases did the extreme bottom eye, and in no case did the extreme top eye, miss. On the whole, the fourth to the eighth eyes from the top of the stick germinated most rapidly. (In one-year cane this would be about the second seed under plantation cutting.) These were followed by the uppermost eyes and the eyes immediately below, which came up together, and then gradually by the rest, the butt eyes being the last to show. The resulting differences in height, while very marked at first, were no longer noticeable after a few weeks. At the time the selection for planting in the progeny test area was made it was noted that the stools arising from sticks taken from uniform stools were on the whole better than those from sticks taken from irregular stools, but that the position of the eye on the stick had no effect on the size of the stool arising from it. Seed from six of these 366 stools was planted in the progeny test area, five of H 109 and one of Lahaina. The rest were discontinued.

EXPERIMENT S 4. Ten small, scrubby sticks of H 109 were chosen from very irregular stools. The other sticks of the stools, while generally of mixed sizes, were always larger than the stick chosen. These sticks were cut into normal sized seed-pieces before planting. This planting was done on June 3, 1920.

On the 1921 survey it was noted that the stools resulting from these small sticks were on the whole very irregular, but four uniformly good stools, one each from four progenies, were selected for planting in the progeny test area.

EXPERIMENT S 5. This experiment, which was planted on June 4, 1920, was designed to test the comparative value of selecting uniformly large stools for seed, as against selecting large sticks regardless of the type of stool from which they are taken. In the stools selected the sticks, always six or more in number, were of a uniform size. The single sticks taken as a check were of the same size as those in the uniform stools, but were taken from very irregular stools. Not more than one stick was taken from any one of these irregular stools, while in the uniform stools all the sticks were taken. Each stick was cut up into seed-pieces, body seed being used as in the previous experiments.

Fig. 2. Erect type.

Fig. 3. Semi-erect type

In 1921, a count of the total number of sticks per line showed no advantage either way, but the lines planted with seed from uniform stools were much more uniform than those planted with seed from irregular stools. A few stools were selected for planting in the progeny test area.

In January, 1920, about 125 more single eyes of H 109 were cut and started, great care being taken in choosing large parent sticks from several stools. It should be noted here that these single-eye cuttings were made by simply gouging out the eye without destroying the stick, which was left standing. In later work this method was changed, the stick being cut up into pieces, each bearing one eye. In the middle of April one hundred of these plants were set out, spaced two and a half feet apart in the row. This planting was not given an S number.

In 1921, twenty-one of these 100 stools were chosen for further progeny planting, data being secured on the number of sticks per stool, relative size and vigor of same, and color and growth types. Tremendous differences were noted, particularly in type of growth. These stools were ratooned, and in 1922 the young ratoons demonstrated these differences to an even more marked degree than did the original stools. Figure 1 shows one of these first ratoon stools.

All the stools selected from these Hamakuapoko experiments were given consecutive numbers in the new progeny test planting, regardless of the experiment from which they were taken. All these progeny plantings were made from three-eye cuttings spaced one foot apart in the row. It might be noted that the space given over to these plantings had been cropped with cane for many years, and more recently had been planted to sweet potatoes. This is mentioned simply to show that any exceptional stand is due to the canes themselves and not to any especially favorable treatment. After making the selections in these Hamakuapoko experiments, all the H 109 cane not planted in the progeny test area, discontinued progenies as well as discarded seed from continued progenies, was planted as crop cane in Field 94, Keahua Section, M. A. Co.

In 1922, a careful survey of the progeny planting was made and data collected. Due to press of time, no tonnage figures were obtained. A few refractometer readings were made, but because of the fact that the instrument was in bad shape, this part of the work was not continued.

Of the 2445 stools comprising the 65 progenies in the test area, 510, or about 21%, were selected for further planting. Only two progenies were discarded entire. Twelve new stools of H 109 were added from the crop cane at the ends of the water-courses, making a total of 522 stools of 75 progenies, which planted about five acres of the extended progeny test area in Field 3. Seventy-four of these progenies are of H 109, the other one being of Lahaina, a stool of which, originally from S 3, seemed in addition to other good qualities to be resistant to root-rot or Lahaina disease.

These progenies were of several types, and the differences between these types were striking. In nearly every case the type characteristics were found to be inherent — that is, the progeny harvested in 1922 was very similar to the mother-stool of 1921. These differences were so obvious in many cases that they were plainly apparent to the casual observer. The Lahaina progeny that

Fig. 4. Recumbent type. This type does not show its recumbent character from the beginning, but the slender, weak shoots will indicate the slender, weak sticks to follow.

Fig. 5. Recumbent bird's nest type.

had attracted attention last year continued to produce good stools, but not sufficiently good to compete in tonnage with the adjoining H 109 progenies.

The ratoons of the 1920 planting were not cut, the plan being to obtain tonnage and juice figures on mature cane, as well as to afford an opportunity for the study of progenies at two years of age.

EXPERIMENT S 6. On June 8 and 9, 1920, a large amount of one-year plant H 109 was selected and cut in Field 91C, Wailuku Sugar Co. The stools chosen, none of which had less than six sticks, were all uniform — that is, the sticks in a given stool were all of approximately the same size, the variation in diameter being negligible. The length, of course, varied with the age of the sticks. The stools were, naturally, not absolutely uniform with each other, some being composed of smaller sticks than others, but an attempt was made to get stools which were approximately uniform with each other. The sticks were generally large, above the average for H 109 of this age. This cane was planted June 9, in Field 96. The plot was intended to serve as an observation test, or as a seed plot if the quality of the cane was markedly better than that of the rest of the field. It was not a progeny planting.

In 1921 the cane on this plot was stripped and a general inspection made. It was found that, while the number of sticks per line was no greater than in the regular plantation cane, they were more uniform and of better size. This experiment showed that carefully chosen seed carefully handled will give a better yield than seed cut and handled in the usual haphazard fashion. This area was used as an observation test only, and no seed was cut or further data taken.

EXPERIMENT S 7. This consisted in an observation test on the growth of exceedingly stunted sticks of late Striped Mexican replant cane in an H 146 field. The stalks taken for seed were less than one-half inch in diameter, and each constituted the only stalk arising from its seed-piece, which in each case was of more than average size.

In 1921 it was found that the stunting in question was purely environmental, the sticks giving rise to normal stools, some of which would pass any reasonable standard set up for original field selections.

EXPERIMENTS S 8 AND S 9. These experiments, which were planted on June 15, 1921, may well be considered together, as the plan and layout were identical, the difference being in the variety of cane employed. S 8 was planted to H 109 and S 9 to Lahaina. They were designed to test the comparative value of selected seed against the regular plantation seed. As in the case of S 6, each stool chosen was composed of uniform sticks, but the stools were not necessarily uniform with each other, although they were as nearly so as possible. As there was neither sufficient seed nor sufficient space available to lay out an experiment on the checker-board plan, the selected seed and the seed furnished by the plantation were planted in alternate lines. The plantation seed was top seed only, while that from the selected stools was top, body and butt seed mixed.

In 1921 it was found that the stand in these experiments was very irregular, due to the fact that considerable hard seed was used, and they were discontinued. However, five stools, four from S 8 and one from S 9, were selected for planting in the progeny test area in Field 100. Another fact which made it

Fig. 6. A choice stool of H 109, consisting of seventeen sticks, grown from ordinary plantation top seed.

seem undesirable to continue these experiments was the discovery that the material used, both plantation and selected seed, was a mixture of several types of each variety. This was quite striking in the case of the Lahaina in S 9.

EXPERIMENT S 10. On June 22 to 24, 1920, about 200 stools of one-year H 109 were cut in Field 91 and planted. The stools chosen were practically all large and uniform. Six sticks per stool was the minimum, unless the sticks were exceptionally good, in which case a stool of five sticks was allowed.

In 1921 this area was gone over carefully and 71 stools selected for further progeny test planting. The stand in this experiment was very uniform, and the stools were well developed. The standard used in selecting these 71 stools was exceptionally high, and many striking type specimens were found.

EXPERIMENT S 11. This experiment, planted in June, 1920, was a replica of S 10, on a smaller scale, except that the cane variety employed was Striped Mexican. A few stools only were chosen, and planted next to S 10.

In 1921 it was found that only two stools in this area were of sufficient value to warrant replanting as progenies, partly because of the numerous Rose Bamboo mutations present.

EXPERIMENT S 12. This was a progeny planting of one stool of D 1135, which consisted of ten very large and uniform sticks and one large sucker. The seed from this stool was planted in June, 1920.

In 1921 it was found that, as the seed had not been spaced, and as the progeny was a prolific stooler, the sticks were quite small, although very numerous. This progeny was left for further observation, but a fire destroyed the material and further work was of necessity postponed.

During July, 1922, H. B. Penhallow, Manager of the Wailuku Sugar Co,, had the ratoon crop of this progeny cut and extended to a little over half an acre, spacing the seed a foot apart. The new stand arising from this spaced planting gives promise of being of great interest, as the young shoots are exceedingly strong.

EXPERIMENT S 13. This was a progeny planting of one stool of H 109 which consisted of 23 sticks. A photograph of this stool is shown on the cover-page of the Record for December, 1921. The cane was planted in June, 1920.

In 1921, four stools, superior to the rest in size and uniformity, were selected and included in the progeny test planting in Field 100. The remainder was left for observation, but was destroyed by a cane fire.

In 1922 the first ratoon crop was cut by the plantation and extended to a half acre, the seed being spaced one foot apart. This progeny maintained its distinctive characters, producing a somewhat erect and heavy stand of cane. The ratoon crop on the original stool in Field 91 was cut and planted in the extended progeny test area in Field 67, Wailuku Section. This ratoon stool consisted of 31 sticks, very much like the 23 sticks of the original stool.

EXPERIMENT S 14. This experiment, planted June 28, was a progeny planting of one stool of Yellow Caledonia, consisting of 23 very large and uniform sticks.

Fig. 7. A fine stool of Lahaina, consisting of twenty-three sticks, grown from ordinary plantation top seed.

Although a fast grower and a heavy stalk producer, this progeny did not reproduce the large stools in 1921, probably on account of close planting. This progeny was not continued as a plant crop, due to the cane fire mentioned above, but the ratoons were continued for further study and were extended to a half acre in Field 89.

EXPERIMENT S 15. This was a small observation test on the use of small sticks for seed. The cane was the so-called D 1135 type of H 109, averaging about ¾ inch in diameter. It was planted in July, 1920.

On the survey in 1921, it showed that small sticks are exceedingly poor planting material. Less than half of the seed germinated, and the stand was very open and irregular.

EXPERIMENT S 16. This was a progeny planting, made in July, 1920, of a very irregular stool of H 109. The entire stool was cut for seed.

In 1921 it was noted that the stand was very poor, the experiment tending to show that progeny plantings should be made from uniform stools only.

In addition to the 82 progenies taken from Experiments S 8, 9, 10, 11 and 13, eight new Lahaina and ten new H 109 progenies were planted in the progeny test area. All seed was spaced a foot apart in the row. The butts and hard seed from these progenies were planted as crop cane along the level ditches. A few photographs showing the different growth types of these progenies were published in the Record for December, 1921. As explained there, those photographs showed the cane at the age of three and a half months. In 1922, when the cane was one year old, the different types of growth were even more apparent than in the young cane.

In June, 1922, a careful survey of all progenies was made, data being taken on color and growth types and on the relative value of each progeny as a whole. Of the 3603 stools comprising these 100 progenies, 420 of H 109, or approximately 14%, and 64 of Lahaina, or about 11%, were selected for further progeny planting. Seven progenies were discarded entire. These 484 stools were planted in Field 67. Thirty new stools of H 109 were added from the crop cane along the ditches, and 42 were selected from fourth ratoons in Field 81. These latter progenies will be followed with particular interest, as they practically all represent one type, and from the size and vigor of the stools selected, this type appears to be very desirable.

Here at Wailuku, as at Hamakuapoko, very striking type differences were found among the progenies, and it was possible to correlate certain growth types with stalk and color characteristics. The Lahaina progenies carried on, although not absolutely characteristic of the variety, seem to represent a superior strain, quite distinctive at certain stages of growth. These Lahaina progenies, together with the one at Hamakuapoko, represent the only selections that have been made in this variety, except for the new ones added at Keahua this year, which will be described later.

All told, there were 167 progenies planted in the Wailuku test area. In addition, a little more than an acre of Lahaina was planted with choice top seed spaced a foot apart, to afford a good opportunity for selection next year.

Fig. 8. An exceptional stool of H 109, consisting of twenty-five sticks, all apparently arising from a single eye.

It might be mentioned here, before describing the 1922 selection work at Keahua, that the Wailuku Sugar Co. is cooperating in this project to the best of their ability, and are carrying on a number of independent experiments along similar lines. They have planted about twelve acres, using Lahaina, H 109, D 1135 and Striped Mexican, involving single eyes spaced 18 and 24 inches, single eyes (Cuban type) spaced 18 and 24 inches, and plantation seed spaced 1 and 12 inches. All the seed used was of excellent quality.

The following quotation is from a letter from H. B. Penhallow, dated August 12, 1922: "Besides the progeny plots which you have planted from time to time, we have planted from the stools selected by you for further observation all the seed you left uncut, in a mixed planting in Field 67. That is, we made no attempt to keep the seed from each stool separate. From the remainder of the progeny fields in 95 and 100 we made a stalk selection, rejecting all undersized cane, and have been able to plant about 40 acres of such selected H 109 in addition to the above. Field 89, in which this years' Experiment Station is located, has been planted with stalk selected Lahaina, and 16 acres in Field 71 with the same, making a total of 66 acres of selected Lahaina. Four acres of stalk selected D 1135 were also planted in Field 71, in addition to that in Field 89. All of this should give us excellent material to work in for further selection next season and furnish good seed for more extended plantings of all the above mentioned varieties. In fact we will have enough such seed for our entire plant area next season, barring circumstances beyond our control. All seed planted this year was far more carefully selected than was the previous practice — all undersized stalks being rejected."

Figures 2, 3, 4 and 5 show some of the different growth types exhibited by stools of H 109 arising from single eyes. The particular specimens photographed were chosen from a large block planted March 10, 1922, by G. B. Grant, at the request of the Wailuku Sugar Co. The photographs were taken June 16.

The summer of 1922 saw the beginning of the selection work in the Keahua section of the Maui Agricultural Co. Approximately 800 stools of H 109 and 300 of Lahaina were selected and marked for cutting in Field 94. About two-thirds of the H 109 stools chosen were in the area previously mentioned as having been planted with the discarded seed from Hamakuapoko. Figures 6, 7 and 8 show three of the stools selected at Keahua, the third one being a stool from the Hamakuapoko "discards." These 1100 stools were cut and planted as progenies the latter part of June.

During July, 1922, some 900 stools of H 109 were selected from one of the best fields on the Puukolii section of Pioneer Mill Co. These stools, which included many good type specimens, have been cut and planted as progenies by the plantation.

Since this report is intended to cover all the Maui progenies, it would be well to mention the share taken by the Olowalu Company in the project. In the fall of 1921 fifty-six stools of H 109 were selected by Mr. Grant from the fields of the Wailuku Sugar Co. and planted at Olowalu. Choice seed of H 109 was secured from the Pioneer Mill Co. and planted in a block adjoining these progenies. In addition, the plantation has selected several hundred stools from their

own fields for a progeny planting. During the present year they have made selections in the block planted with the seed from Pioneer, as well as reselecting in the Wailuku material.

In conclusion it might be stated that in the writer's opinion, based on the data obtained thus far, a system of selection according to type characteristics seems to be the most speedy and practical method of arriving at the desired results.

D 1135 and Yellow Tip at Honokaa.

The Honokaa Sugar Company has supplied us with the results of a test which was recently harvested on that plantation, comparing D 1135 and Yellow Tip.

The cane was plant in an upper field at 1300 feet elevation. In this upper field the Yellow Tip gave better yields than did D 1135. This is in line with general results elsewhere. As a general rule, at elevations of 1200 to 1500 feet and up, Yellow Tip will do better than most other canes. A strong item in its favor is its good ratooning powers.

At the present time, the best results are being obtained on Hawaii by planting Yellow Caledonia at the lower elevations, D 1135 in the middle and the Tip canes at the highest elevations.

In former years the Tip canes found much favor in Hamakua, but they were forced out of cultivation, to a large extent, by Yellow Stripe disease.

Both Yellow Tip and Striped Tip are extensively planted in the Kohala district. Yellow Tip, especially, is being planted in the upper fields in the Hilo district. In neither of these districts are these canes suffering badly from Yellow Stripe at the present time.

We believe it both feasible and advisable to again try the Tip canes in the upper Hamakua fields. Good, sound seed should be obtained, preferably from Kohala, and a few fields planted for trial, very careful watch being kept in the meantime for Yellow Stripe, particularly when planting new fields. It is possible that by careful selection of seed Yellow Stripe may be kept in control and good yields of sugar obtained.

The results obtained in the Honokaa test are given as follows:

Plot No.	Variety	T. C. P. A.	Q. R.*	T. S. P. A.
1	D 1135	24.1	9.17	2.63
3	D 1135	25.46	8.54	2.98
4	D 1135	30.74	8.59	3.58
6	D 1135	26.85	8.43	2.69
7	D 1135	25.91	8.69	2.98
9	D 1135	23.8	8.96	2.66
	Average..	26.14	8.73	2.99
2	Y. T.......	32.39	9.36	3.46
5	Y. T.......	29.44	9.57	3.08
8	Y. T.......	32.95	9.56	3.45
	Average..	31.59	9.50	3.33

* Quality ratio based on first mill juices.

Within recent years a number of seedlings have been propagated from the Tip varieties. These are now under trial. Additional seedling work is contemplated, using Yellow Tip and Striped Tip as parent canes. By obtaining crosses between these varieties and D 1135, Badila, and other canes, we hope to secure seedlings that retain the vigor of growth at high elevations that is so characteristic of the Tip canes, combined with the resistance to Yellow Stripe disease commonly met with in varieties such as D 1135.

J. A. V.

Field Distribution Record of H 109.

Herewith is presented a graphic method of recording the field distribution of sugar cane varieties originated by H. B. Penhallow, Manager of the Wailuku Sugar Company and applied to H 109 for illustration.

The figures opposite the field numbers below the circles show the approximate percentage of seed used in planting a field where there was more than one source of supply. The heavy line connecting two circles shows the source of the largest quantity of seed used, or predominant strain.

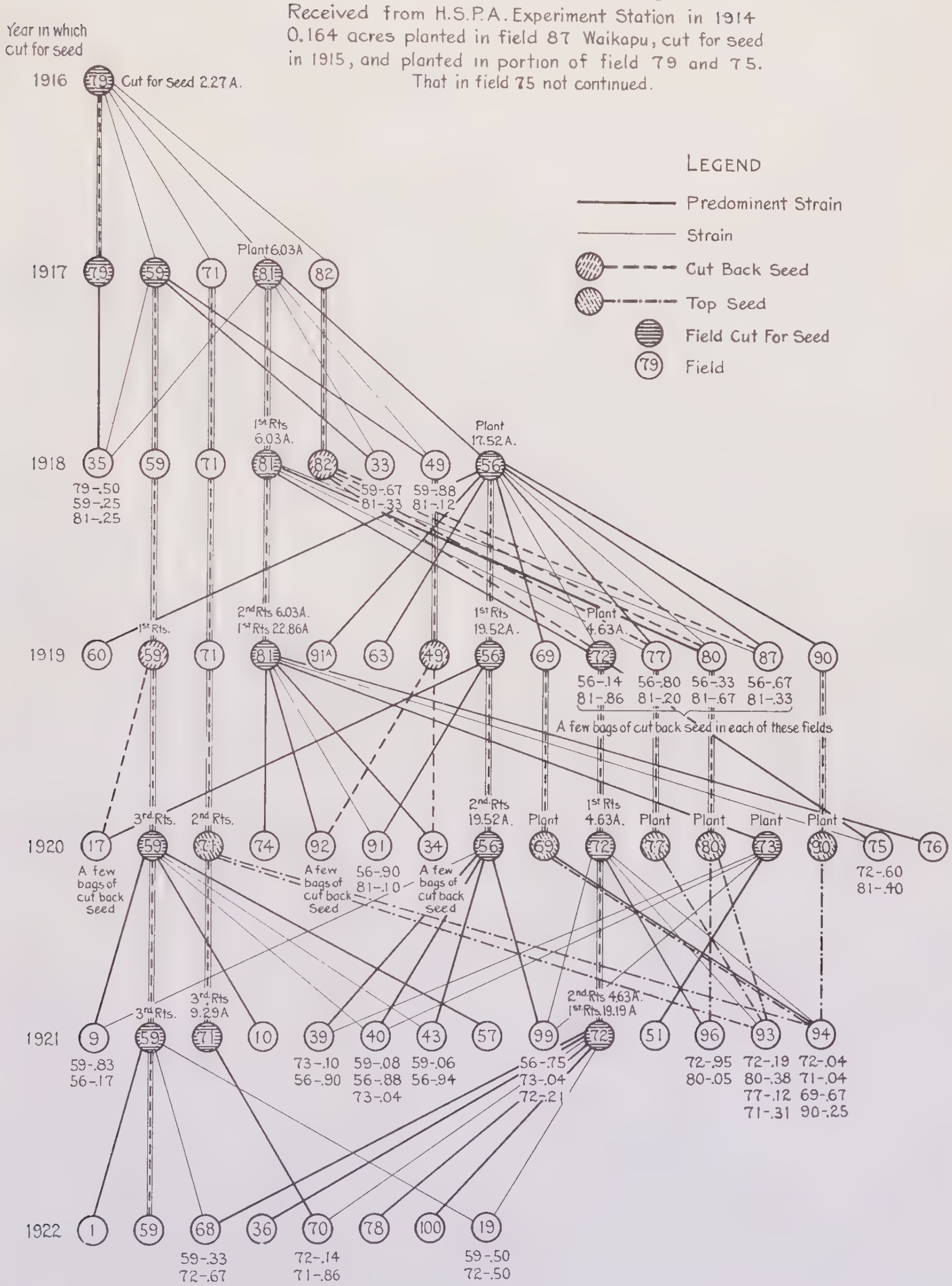
By referring to the legend on the chart the other types of lines will indicate the kind of seed used. Body seed was taken for planting, unless otherwise indicated by the line connecting the seed source with the field in which it was planted.

This graphic method can be used to good advantage in studying and recording the performance of selected canes and their progeny.

In addition to indicating the distribution, any other data may be recorded, as, for example, the tracing of the source of seed cane of outstanding fields—by recording the acreage yields or other notable features.

Field Distribution Record
H109 Seed
Wailuku Sugar Company

Received from H.S.P.A. Experiment Station in 1914 0.164 acres planted in field 87 Waikapu, cut for seed in 1915, and planted in portion of field 79 and 75. That in field 75 not continued.



Phosphoric Acid and Potash in Hamakua.

Hamakua Mill Company Experiments 3 and 5, — 1922 Crop.

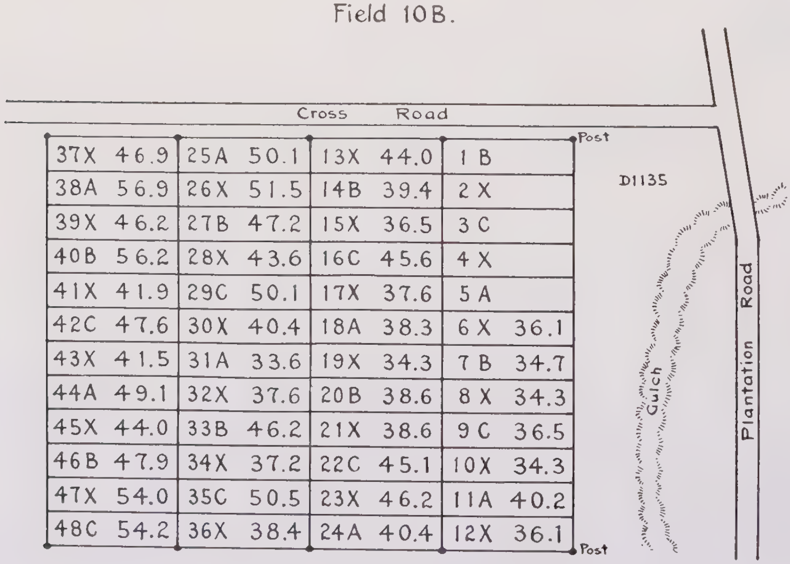
These two experiments were planned to determine the need of phosphoric acid and of potash at Hamakua.

Experiment 3 was laid out at Hamakua Mill in field 10B at an elevation of 1300 feet. Experiment 5 was in field 35, Kukaiau. The cane in both cases was plant, that in No. 3 being D 1135 and that in No. 5 being Yellow Caledonia. All plots received 155 pounds of nitrogen per acre from 1000 pounds of nitrate of soda. Some plots received no further fertilization; one series received 360 pounds of muriate of potash in addition; to another series 900 pounds of acid phosphate were added to the nitrate application. A fourth lot of plots got both the potash and the acid phosphate.

Plant Food Requirements

Hamakua Mill Co. Exp. 3, 1922 Crop

Field 10B.



Summary of Results

Plot	No. of Plot	Treatment			Yield Per Acre	
		N.	P_2O_5	K_2O	Cane	Sugar
X	24	155 *	–	–	41.05	5.64
A	8	155 *	–	150 *	44.09	6.06
B	8	155 *	150 *	–	44.31	6.09
C	8	155 *	150 *	150 *	47.06	6.46

At Hamakua Mill, in experiment No. 3, the results show a very definite response to both phosphoric acid and potash, amounting to about 0.40 ton of sugar for either one. The gain amounted to 0.90 ton of sugar when both of the ingredients were used on the same plots.

At Kukaiau, on the other hand, there was no response from either potash or phosphoric acid. The plots fertilized with nitrate of soda only gave yields just as good as did the plots where complete fertilizer was applied.

The results obtained from these two experiments are given in the following tables:

PLANT FOOD REQUIREMENTS
Hamakua Mill Co. Exp. 5, 1922 Crop
Field 35. (Kukaiau)

Summary of Results

Plots	No. of Plots	Treatment			Yields Per Acre		
		N.	P_2O_5	K_2O	Cane	Q.R.	Sugar
X	23	155"	–	–	36.47	7.23	5.04
A	7	155"	–	150"	37.16	7.71	4.82
B	8	155"	150"	–	36.18	7.38	4.90
C	8	155"	150"	150"	36.71	7.78	4.72

HAMAKUA MILL EXPERIMENT 3,—1922 CROP.

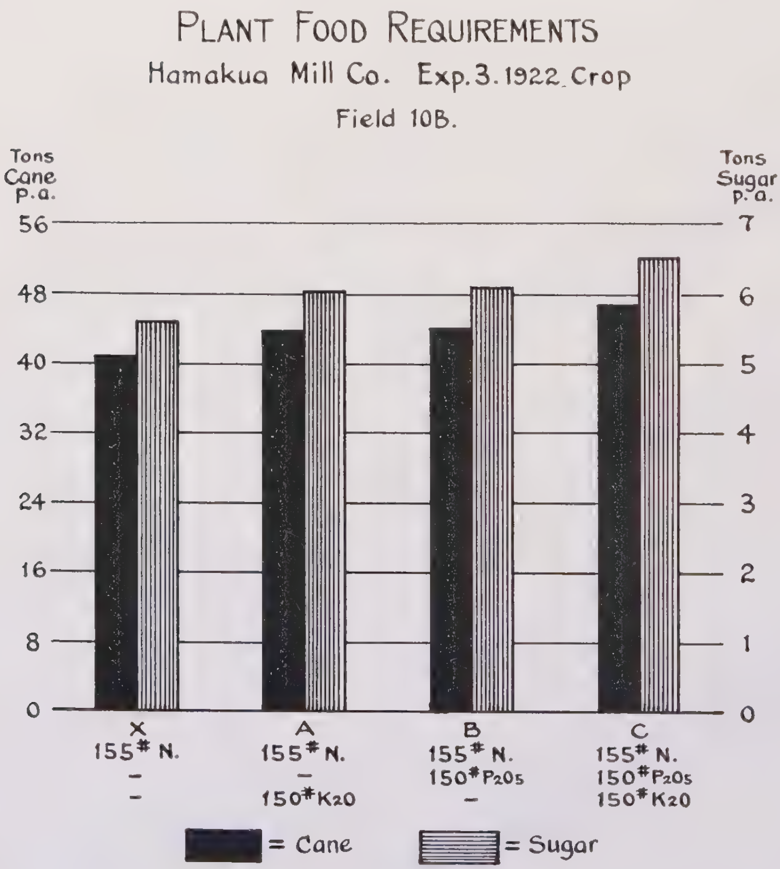
Treatment	Yield per Acre	
	Cane	Sugar
Nitrogen and phosphoric acid	44.3	6.09
Nitrogen only (adjoining plots)	41.4	5.69
Nitrogen and potash	44.1	6.06
Nitrogen only (adjoining plots)	41.4	5.68
Nitrogen, phosphoric acid and potash..	47.1	6.46
Nitrogen only (adjoining plots)	40.4	5.54

HAMAKUA MILL EXPERIMENT 5,—1922 CROP.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nitrogen only	36.5	7.23	5.04
Nitrogen and phosphoric acid	36.2	7.38	4.90
Nitrogen and potash	37.1	7.71	4.82
Nitrogen, phosphoric acid and potash..	36.7	7.78	4.72

Details of Experiment.

HAMAKUA MILL CO. EXPERIMENT 3,—1922 CROP.



Object:

To determine the plant food requirement of sugar cane on the soils of Hamakua district. The comparison is made between:

(1) Nitrogen alone;
(2) Nitrogen and potash;
(3) Nitrogen and phosphoric acid;
(4) Nitrogen, potash, and phosphoric acid.

Location:

Hamakua Mill Co., Field 10B (elevation 1300 feet).

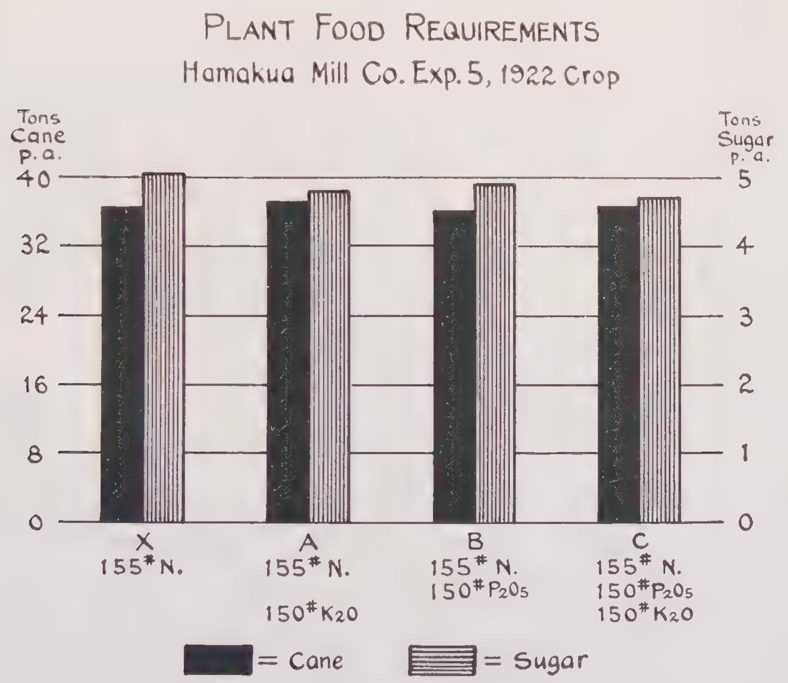
Crop:

D 1135, plant cane (planted March, 1920).

Layout:

Number of plots = 48.

Size of plots = 1/15 acre, consisting of 6 lines, each line 4.625 feet wide and 104.65 feet long.



Fertilization — Pounds per Acre:

Plots	Number of Plots	May 19, 1920		July 1, 1920	Nov. 1, 1920	Mar. 1, 1921	Total		
		Mur. Pot.	Ac. Pho.	N. S.	N. S.	N. S.	N.	K_2O	P_2O_5
X	24	...	....	300	400	300	155	...	...
A	8	360	....	300	400	300	155	150	...
B	8	...	900	300	400	300	155	...	150
C	8	360	900	300	400	300	155	150	150

Muriate of potash, 42% K_2O. Acid phosphate, 17% P_2O_5. Nitrate of soda, 15.5% N.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.

Hamakua Mill Company Experiment 5, — 1922 Crop.

Object:

To determine the plant food requirement of sugar cane on the soils of Hamakua district. The comparison is made between:

(1) Nitrogen alone;
(2) Nitrogen and potash;
(3) Nitrogen and phosphoric acid;
(4) Nitrogen, potash, and phosphoric acid.

Location:

Hamakua Mill Co., Field 35 (Kukaiau).

Crop:

Yellow Caledonia, plant cane (planted April 15, 1920). Field fallow in 1919; 1500 pounds lime per acre applied before planting.

Layout:

Number of plots = 46.

Size of plots = 1/15 acre, consisting of 6 lines, each 5.25 feet wide and 92.2 feet long.

Plan:

Fertilization — Pounds per Acre:

Plots	Number of Plots	May 29, 1920		July 1, 1920	Nov. 1, 1920	Mar. 1, 1921	Total		
		Mur. Pot.	Sup. Phos.	N. S.	N. S.	N. S.	N.	K_2O	P_2O_5
X	23	...	...	300	400	300	155	...	...
A	7	360	...	300	400	300	155	150	...
B	8	...	900	300	400	300	155	...	150
C	8	360	900	300	400	300	155	150	150

Nitrate of Soda = 15.5% N.
Muriate of Potash = 42% K_2O.
Superphosphate = 17% P_2O_5.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.

J. A. V.

Phosphoric Acid in Cane Juices.

A Possible Indicator of Fertilizer Needs.

By Herbert Walker.

Summary.

The direct determination of plant-food ingredients in cane juices is suggested as a logical and easily applicable means of getting an approximate idea of the fertilizer requirements of cane soils. A large number of P_2O_5 determinations in crusher juices indicated that this element was fairly constant for a given field and, in general, for a given elevation, although marked differences existed between canes grown at different elevations, the lower fields producing juice containing the most P_2O_5. As a preliminary standard .020% P_2O_5 (grams per 100 cc. crusher juice) is suggested. Fields averaging above this figure probably contain sufficient available P_2O_5 for maximum cane yields; a lower figure calls for field experiments. Where juices run less than .010%, some phosphate should be applied as a precaution, even in the absence of experimental proof that it is needed. Similar work with potash is planned.

While it is generally recognized that carefully controlled field experiments afford the only reliable means of knowing the fertilizer requirements of a cane soil, quicker methods of getting this information are much to be desired. Soil analyses alone, except in the few cases of extreme deficiency of some element, are not of much value; the plant food may be there, but for some unknown reason, be it chemical, physical, or biological, may not be available to the plant. Soil chemists are still trying to devise methods of extraction which shall imitate plant-root action and yield a solution containing the available plant-food in soil.

A so-called "physiological" method of soil analysis has been suggested from time to time by various investigators, but does not seem to have been tried out to any great extent. According to this method the amount of plant food available in a soil is indicated (relatively) by ash analyses of crops grown in it. The difficulty in getting representative samples and reducing them to ash for analysis is probably one reason why this method, which otherwise appears very practicable, has not been more extensively worked out. This difficulty was partially overcome by Burgess,[1] who compared the analyses of final molasses from a large number of plantations and pointed out the fact that "there exists a definite relationship between the percentage of potash present in the soils of a given region and that found in the final molasses from that section." He further suggested that "where a mill consistently produces a molasses which carries less than 2.5% to 2.75% of potash, or where the molasses ash runs less than 20% to 22% potash, field experiments with potash fertilization, at different locations on the plantation, might be profitably made."

The relationship between low potash content of molasses and the need of potash fertilization has been partially confirmed. The majority of field tests

[1] Hawaiian Planters' Record, Vol. XIX, p. 421.

made throughout the Islands has shown little or no increased yield of sugar from the application of potash fertilizers. The few soils which have responded are from those districts whose final molasses runs much lower than the average in potash.

A serious drawback to the use of molasses analyses for other than very general conclusions is the difficulty of determining from what particular field a sample of molasses has been derived. The average output of a plantation might show it to be, on the whole, well supplied with potash even though certain fields were very deficient. Also, potash is the only element determinable by this method, since most of the nitrogen and phosphoric acid is eliminated in the process of manufacture.

A procedure which would appear to have most of the advantages and few of the disadvantages of plant ash or molasses ash analyses is the direct determination of plant food ingredients in the cane juice. Samples can readily be obtained from the crusher or first mill during the grinding season without in any way disturbing factory or laboratory routine. Nearly all factories make a practice of taking separate samples of juice from each field for brix and polarization, and portions of these can be set aside for plant food analyses. A crusher juice sample from a few cars of cane covers considerable field area and should be fully as representative as a composite soil sample from the same location. Theoretically this method, once properly correlated with fertilizer experiments in the field, seems very logical. Instead of trying to imitate Nature by extracting soil in the laboratory with weak acids, supposed to approximate the action of plant roots, we let the cane prepare its own "soil solution" and submit it to us ready made for analysis. That the relative amount of plant food actually taken up is in some degree a measure of its availability seems a reasonable assumption.

Establishing a numerical relationship between percentages of mineral constituents in cane juice and the fertilizer requirements of a field has yet to be worked out. It may or may not be possible. We have made a start at least at this plantation by determining phosphoric acid in the crusher juice from each field ground during the last two months of the season. Some seventy analyses were made, covering twenty-eight different fields. The analytical work was done by George B. Glick, chief chemist of this factory, using a method adopted by W. R. McAllep for phosphoric acid determinations in connection with clarification experiments.

VOLUMETRIC P_2O_5 DETERMINATION IN CANE JUICE.

(See Sutton's Volumetric Analysis.)

SOLUTIONS.

A — 10% NH_4OH.

B — Acetic Acid.

C — 10% Sodium Acetate.

Dissolve 100 grams sodium acetate in water, add 50 cc. glacial acetic acid and make up to 1 liter.

D — Standard Uranium solution. One cc. = 0.005 gm. P_2O_5.

This may be either acetate or nitrate. Thirty-five grams per liter is the approximate amount, using either salt. If nitrate is used add 50 cc. glacial acetic acid or a correspond-

ing amount of weaker acid per liter. Excessive exposure to light reduces this solution.

Standardize against tri-basic calcium phosphate.

Indicator. Powdered crystals of potassium ferrocyanide.

Procedure. To 100 cc. of juice add 1 cc. NH_4OH solution, acidify with acid and add 10 cc. of the sodium acetate solution. Titrate with the standard uranium solution using powdered potassium ferrocyanide on a drop reaction plate as an indicator. The solution will usually settle sufficiently to pipette off a small portion of clear liquid for the end point determination.

Nearly the whole of the uranium solution should be added in the cold and the titration finished in the hot solution (90–100° C.).

The method usually gives duplicate results on the same juice which vary not more than .002% P_2O_5.

After the juices from a few fields had been analyzed it became evident, first, that different samples from the same field usually showed very little difference in phosphoric acid, and, second, that there was a very decided difference between juices from different parts of the plantation. At least three crusher juice samples, taken on different days, were analyzed from each field, when possible.

A few examples of analyses from Wahikuli section will illustrate the variations in amount of phosphoric acid:

Field	I 8 L	H 8 P	E 5 P
Approximate elevation	50 ft.	200–300 ft.	800–900 ft.
Grams P_2O_5 per 100 cc. crusher juice	.062	.023	.015
" " " " " "	.060	.025	.012
" " " " " "	.067	.023	.013
Average	.063	.024	.013

These figures are fairly typical of the plantation as a whole. The juices from fields nearest sea level are rather high in phosphoric acid, those from the central portion, up to about 500 feet elevation, are moderately well supplied, while the highest areas are lowest in phosphate. This tendency has been so uniform that in the case of the fields thus far examined it would be possible, with the aid of a contour map, to predict fairly well the amount of phosphoric acid to be expected in the juice from any field. Exceptions to this rule may be found in some of the red soils at the north end of the plantation. Most of the cane from these fields had been harvested before phosphoric acid determinations were started, but the two samples we were able to get ran rather low in phosphoric acid, although from a moderate elevation.

Interpretation of Results.

With so little data available, any attempt to draw fixed conclusions in regard to phosphoric acid requirements of all the fields tested so far would be dangerous. G. R. Stewart of the H. S. P. A. Experiment Station is analyzing a large number of soils from different sections of the plantation which, by comparison with juices from the same fields, may show relationship between phosphoric acid in the soil and that taken up by the cane.

Variety of cane, as between Lahaina, H 109, Striped Mexican and D 1135, apparently does not influence the amount of phosphoric acid absorbed, nor have we found any noticeable difference in this respect between plant and ratoon cane.

Our lower fields generally yield more cane per acre, but with lower purity juice, than the uplands. This is probably due to other causes than phosphoric acid. Most of the lower fields are irrigated with pump water of a rather high salt content, and have plenty of it, while the upper areas have a purer water supply, but are more dependent on weather conditions. The fields cited happen to be exceptions to the general rule that our lower fields give higher yields of cane. I-8, long ratoons, the lowest in elevation and highest in phosphoric acid, yielded only 39 tons per acre of Striped Mexican cane; H-8, plant, yielded 43 tons per acre of H 109 cane; and E-5, plant, yielded 72 tons per acre of Striped Mexican. The crusher juice from I-8 averaged 21.51 brix and 84.52 purity; H-8 was 19.82 brix and 86.73 purity, and E-5 was 20.39 brix and 90.44 purity, yielding 10.3 tons sugar per acre. Evidently this cane could not have suffered much from its lack of phosphoric acid. Its subsequent ratoon yields will be of interest.

The inference from results obtained in field E-5, that all soils capable of yielding .013% phosphoric acid to the juices of cane growing in them contain a sufficient supply of available phosphoric acid, may be premature; it certainly seems logical to reason that phosphoric acid is not the limiting factor in the case of I-8, with nearly five times as much in its juice, and probably not in H-8. Field experiments harvested last year from B-6 at about 400 feet elevation indicated little or no gain from phosphoric fertilization.

Neighboring fields at about the same elevation harvested this year had about .025% phosphoric acid in crusher juice.

We have lately laid out several plant food field experiments at higher elevations, which, when harvested, should help correlate phosphate needs with phosphates in the juice. It is quite possible that even the poorest fields on this plantation may have enough phosphoric acid for their immediate needs.

There is the further possibility that cane juices will always contain a certain minimum amount of P_2O_5 and that its lack in the soil will be followed by less cane yields rather than by a further diminution of P_2O_5 in the juice. A field test made by the Experiment Station at Oahu Sugar Company yielded a large increase in sugar by the application of 90 pounds P_2O_5 per acre to a soil containing 0.16% total HCl soluble P_2O_5 of which 0.0024% was soluble in 1% citric acid. Juices from the plots receiving no phosphoric acid contained .008% P_2O_5; those from plots receiving 90 pounds phosphoric acid per acre had .010% P_2O_5.

While we may never be able to conclude definitely from a juice analysis alone that a field needs phosphate fertilizer, a relatively high figure for P_2O_5 in the juice very probably will indicate that such fertilization is not needed, and thus by elimination help to locate field experiments where they are most necessary.

As a basis for future work along this line I would submit the following:

Soils yielding cane with a phosphoric acid content of more than .020% in its juice probably contain enough available phosphoric acid and are not in immediate need of phosphate fertilizers.

Where the juice contains less than .020% P_2O_5, phosphates may be advantageous. Field experiments should be made to determine this point.

Where the juice contains less than .010% P_2O_5, the soil will probably respond to phosphate fertilizers and their moderate use should be continued even though no immediate gains are shown by field trials.

An interesting correlation between field and factory work is worthy of note in this connection. Messrs. McAllep and Bomonti,[1] in their studies on clarification of cane juices, found that the completeness with which a cane juice may be clarified depends very largely on the amount of phosphoric acid it contains, and placed the approximate limit, below which clear settled juices are not apt to be obtainable, at .030% P_2O_5. According to this, the first aid to determine which fields need phosphates would be a consultation with the sugar boiler. Those fields which consistently yield well settled, brilliant, clarified juice may be dismissed at once as not in need of phosphoric acid, and more consideration may be given to fields whose juices clarify less readily.

In this paper special attention has been paid to phosphoric acid. The same line of reasoning would apply to the determination of potash and nitrogen in cane juices, although experience has shown that nearly all Hawaiian soils respond to nitrogen, while comparatively few are in need of potash. Mr. Glick is planning to work out a simplified method for potash in juices in order to find out what differences in this element, if any, our fields may show.

Pioneer Mill Co., Lahaina, Maui.

[1] Hawaiian Planters' Record, Vol. XXVI, p. 122.

Badila and Yellow Tip at Kilauea.

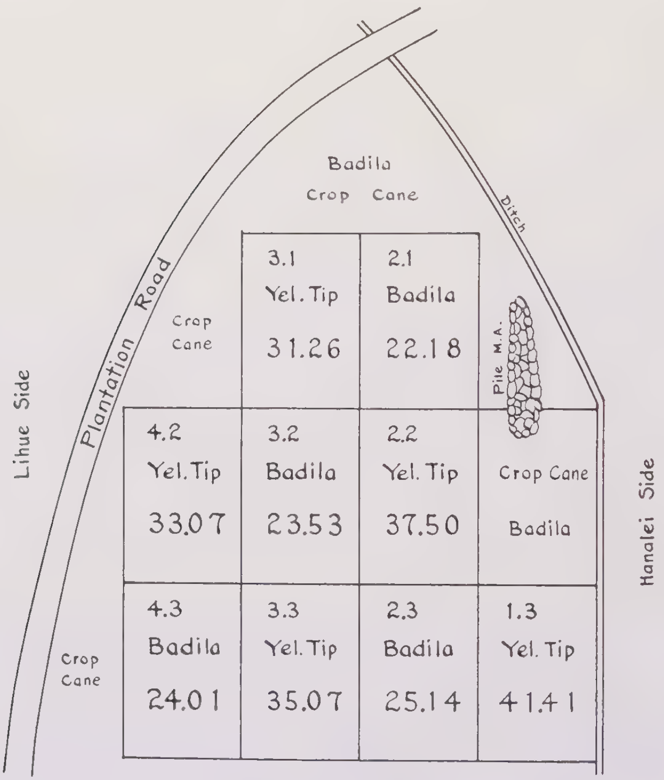
KILAUEA EXPERIMENT 32,—1922 CROP.

In this experiment Badila and Yellow Tip varieties are compared in one of Kilauea's most mauka fields. The soil is poor and the climate is perhaps as bad for cane growing as at any place on the plantation.

VARIETY TEST

Kilauea Sugar Plantation Co. Exp. 32, 1922 Crop

Field 37.



Summary of Results

Plots	No. of Plots	Yields Per Acre		
		Cane	Q. R.	Sugar
Badila	4	23.71	9.54	2.48
Yellow Tip	5	35.76	9.98	3.58

The cane was planted in October, 1920. All plots received uniform applications of fertilizer at the rate of about 150 pounds of nitrogen per acre, 500 pounds of molasses ashes and 1000 pounds of raw rock phosphate per acre.

In the earlier stages of the experiment the Badila cane looked better than the Yellow Tip, but after about eight months the Tip cane seemed to get a somewhat better color and to hold it throughout the remainder of the growing period.

At the time the cane was harvested the Tip cane had a much heavier stand on the ground. It had stooled out more. It was apparently still growing while the Badila was fully matured. The Badila cane was badly rat eaten. A very high per cent. of the stalks was bitten off about half way up and the entire top half rotted or eaten on the ground. The Tip cane was far less rat eaten. If the rats could have been eliminated the Badila cane would have undoubtedly shown 50 per cent. higher returns.

The yields of cane and sugar are given in the following table:

Plots	Cane	Quality Ratio	Sugar
Badila	23.71	9.54	2.48
Yellow Tip	35.76	9.98	3.58

The Yellow Tip cane averaged 12.05 tons more cane and 1.10 tons more sugar per acre than the Badila. The experiment will be continued on the ratoon crop.

Details of Experiment.

Object:

To compare Badila and Yellow Tip varieties of cane on mauka, unirrigated land at Kilauea.

Location:

Field 37.

Crop:

Badila and Yellow Tip plant cane.

Layout:

Number of plots = 9.
Size of plots = 1/10th acre (80.6′ x 54′).
Plots consist of 12 straight lines each 80.6′ by 4½′.

J. H. M.

Notes on the Results Achieved to Date in the Introduction to the Fiji Islands of Certain Parasitic and Predaceous Insects.

By Robert Veitch.

Since 1911 a number of parasitic and predaceous insects have been introduced to the Fiji Islands for the purpose of controlling the more important pests, and the time now seems opportune for recording the results achieved in these various introductions.

In 1911 the late Mr. Terry sent two boxes of lantana berries from Honolulu to Mr. Jepson, then Government Entomologist in Fiji; a few lantana seed flies *(Agromyza* sp.) emerged from the material received and these were liberated in Suva. Writing in 1916, Mr. Jepson states: "It is satisfactory to record that this fly is now thoroughly established in Fiji, and it is not possible to find lantana within several miles of Suva which does not display evidence of attack by this insect." In the same report he says: "Dissection of the berries also shows that 95% of the berries are attacked by the larvae of this useful fly"; he also adds, "There is unfortunately in Fiji a small parasite *(Chalcididae)* of the lantana seed fly, but it is not sufficiently numerous to affect the propagation of the fly to any serious extent."

A second introduction of Jepson's was *Plaesius javanus* Er., a Histerid predator of the banana borer *(Cosmopolites sordida* Chevr.); in his search for enemies of the sugar-cane borer Mr. Muir discovered this predator in Java, and in 1913 Mr. Jepson successfully transported and liberated 3,500 beetles on seven different banana plantations in Fiji. The beetles were found to be breeding quite freely four months after liberation, but they were then lost sight of and a further supply of beetles was imported by post from Java in 1918. The first evidence of their permanent establishment was obtained in 1921, when Mr. McNamara, of the Inspection Staff of the Department of Agriculture, obtained a specimen of the beetle on Nabalau Estate; its effect on the banana borer position has not yet been definitely ascertained.

The attempt to establish *Ceromasia sphenophori* Vill. (the New Guinea parasite of the sugar-cane borer, *Rhabdocnemis obscura* Boisd.), commenced in 1910 with the colony left by Messrs. Muir and Kershaw at Nausori Mill, where they established an intermediate breeding station when transporting the parasite from New Guinea to Hawaii; great efforts were made to establish the parasite throughout Fiji, and no fewer than twelve of the officers of the Colonial Sugar Refining Company were engaged on the work of breeding the parasite at various centers. In the main sugar growing districts at Lautoka and Rarawai the parasite has failed completely so far and a similar fate attended the efforts to establish it at Labasa; it was believed that the colonies liberated at Nausori had also died out, but in 1920 Mr. Pemberton, who was then at Nausori Mill, discovered that the parasite was actually established. After a thorough examination of the

position towards the end of 1920 the writer was convinced that the parasite had been responsible for a very marked improvement in the borer position at Nausori and a further investigation of the position in 1921 served to strengthen that belief; it is to be hoped that the present satisfactory position at that mill is maintained. In 1909 the percentages of Malabar (Yellow Caledonia) and Badila harvested were almost exactly the same as in 1920 and it may be said that the relative proportions of the two varieties were the same in these two years. It is therefore impossible to attribute to a change of variety the fact that in 1909 the borer damaged stalks amounted to 15% of the total received at the mill, while in 1920 the figure had fallen to 5%. The parasite alone must be given the credit for this great improvement and the writer has no hesitation in claiming that its establishment at Nausori has led to the saving of thousands of pounds annually at that mill. A further determined effort is being made to establish the parasite at Labasa, where borer damage is very serious; at present nothing is being done at Lautoka and Rarawai, where damage is not nearly so extensive. It will be no easy task to establish the parasite at Labasa, but the success at Nausori amply justifies the new attempt. In addition to the original colony brought by Messrs. Muir and Kershaw from New Guinea, colonies have been brought from Hawaii by Mr. North, Dr. Illingworth and the writer; two colonies were also sent to the Vancouver-Fiji Sugar Company.

The writer brought over a large colony of *Scolia manilae* Ashm. from Hawaii in 1917 and liberated some six hundred specimens in the sugar-cane fields of the Sigatoka district where it was hoped it would attack the white grubs of *Adorctus versutus* Har. and *Rhopaea vestita* Arrow.; unfortunately a very heavy flood submerged the whole of the area on which the parasite had been liberated three weeks earlier. Frequent careful examinations have failed to reveal any trace of the Scoliid, but it may eventually be recovered; in captivity it was successfully reared from grubs of the Fijian species.

In 1920 Mr. Simmonds, Acting Government Entomologist in Fiji, visited Tahiti for the purpose of introducing two parasites to assist in the control of the transparent cocoanut scale (*Aspidiotus destructor* Sign.). Reporting on a visit of inspection to the island of Moturiki, where a colony of the imported Tahitian parasites had previously been liberated, he states in June, 1921: "On examination of the affected area the large yellow Chalcid, *Aphelinus chrysomphali,* was found to be well established and doing good work, but the smaller species, *Aspidiotiphagus citrinus,* was not observed except in the pupa state on some of the trees just recently placed there." Continuing his journey to Bureta on the island of Ovalau, he found that *A. citrinus* was "numerous and well established," and he states, "It is satisfactory to find that both parasites are now well established."

The above paragraphs will serve in some measure to indicate the amount of progress achieved in this important branch of economic entomology and they demonstrate how deeply indebted Fiji is to Hawaiian entomologists and their supporters.

Lautoka, Fiji.

A Paper Laying Machine.

The results already obtained indicate that the use of paper as a mulch over the soil above the roots of pineapple plants is destined to become a common practice in the pineapple agriculture of the future.

The adaptation of the paper mulch to pineapple culture has been a very simple matter, requiring only slight deviation from planting methods already

DOTY-WENDT PAPER LAYING MACHINE.

in vogue. A suitable bed of earth is first prepared to receive a row of pineapples; the paper is then applied to this bed in long strips, its edges being held down by a covering of soil; and the pineapple plants are inserted through holes made in the paper at proper intervals.

Up to the present time, the preparation of the bed and the laying of the paper has been done by hand and, consequently, at considerable expense. The machine illustrated herewith prepares the bed, lays the paper and covers its edges in one operation and at very moderate expense. It may be drawn by mules or by a light tractor.

There are three essential parts to this machine, each part performing a definite function:

(1) A plank drag-sled which pulverizes the soil and forms it into a bed of the desired shape to receive the paper;

(2) A flanged roller or spool which is attached to the rear of the sled and shapes the paper over the bed, turning its edges down into the furrows made by the sled runners; and

(3) Shovels or disks which are placed just back of the flanged ends of the roller and which serve to throw the soil against and over the edges of the paper.

The sled may be modified to draw the soil into a bed of any shape desired. The spool should be shaped to conform to the crown of the bed, its barrel being cylindrical if the top of the bed is to be flat and concave if the top of the bed is to be curved.

H. L. L.

The Analysis of Ash in Cane Sugar and Molasses.

By H. A. Cook.

It has long been known that the factor .9 for converting sulfated to carbonated ash, originally adopted for work with beet products and now in use by cane sugar chemists, is greatly in error. There has been considerable agitation within recent years among sugar chemists to do away with the present factor and adopt one that would give more nearly the correct results.

Most of the work that has been done in the comparison between the two methods has been in connection with sugar beet products. In that connection a number of able chemists have protested against the present factor. Among them reference can be made to Violette,[1] who, operating upon a large number of beet sugars of different grades, showed that a deduction of one-fifth is more applicable to all products, excepting high grade sugars, for which a value of three-tenths should be used. Among others in the beet work can be cited the following, who all arrived at about the same conclusion: Dubrunfraut,[2] Girard,[3] Grobert,[4] Boyer,[5] Paszosski,[6] Courtonne,[7] and Mintz.[8] A. Schweizer,[9] referring to work on four molasses, says, "From these figures it is also seen that an assumption of a difference of ten percent between carbonated and sulphated ash is wholly inaccurate, since in the case of the above four molasses the differences are 18, 12, 22 and 22 respectively." Jar. Mekolasek[10] has found that determinations of the ash of beet molasses obtained during the past four campaigns in Bohemia by the two methods show that instead of ten percent, the average deduction works out at 21.44 percent.

In regard to the sugar cane and its products the number of references are comparatively few. J. P. Ogelvie and J. H. Linderfield,[11] working with beet sugars and molasses and also cane sugars and molasses, found that with cane sugars the values were very irregular, varying from 6 to 25 percent, with an average of 14 percent, while with cane molasses the values were reasonably constant, namely, 14 to 21 percent, with an average of 18 percent. Hamakers[12] has calculated from the average composition of cane sugar ash that the deduc-

ton should be about one-fourth. Weichman[13] has stated that "the subtraction of one-tenth is generally assumed to answer for beet sugars, but is entirely misleading when cane products are being analyzed, because the ash of the latter possesses a composition entirely different from that of the former." Noel Deerr[14] says, "The continued use of the ten percent reduction is an instance of the persistence of a once accepted error in spite of numerous protests."

Considerable work has been done at this Station on the ash of cane sugar. J. M. Reynolds obtained the comparison of the two methods on one hundred samples of cane sugar. At the same time A. Brodie obtained the comparisons on one hundred and fifty samples of cane sugar. These samples represent over 95 percent of the factories in the Islands.

The great majority of these sugars polarized between 96.0 and 97.0. Some varied from 94.5 to 96.0, while some were between 97.0 and 98.0. The ash, in terms of sulfated ash less ten percent, varied from 0.21 to 2.64 percent.

The following table gives the averages of the results obtained by Mr. Brodie and Mr. Reynolds:

	Number Samples	Sulfated Ash	Normal Ash	Average Difference	Factor
Brodie	150	.735	.579	21.22	.788
Reynolds	100	.700	.550	21.43	.786
Average ...	...	.7215	.5687	21.30	.788

The above figures indicate a factor for converting sulfated to carbonated ash of .79. Thirty-one samples had a factor of .79.

From a study of the figures obtained by Mr. Brodie and Mr. Reynolds the following chart can be constructed:

Number of Samples With Factor Below .700	Number of Samples With Factor Between .700 and .750	Number of Samples With Factor Between .750 and .800	Number of Samples With Factor Between .800 and .850	Number of Samples With Factor Between .850 and .900	Number of Samples With Factor Over .900
4	46	98	82	17	3

The results are similar to those of J. P. Ogelvie and J. H. Linderfield in that they show a wide variation in the values for cane sugar.

To determine whether or not there was volatization in burning a carbonated ash a large number of carbonated samples were treated with sulfuric acid and reignited. In all cases the agreement was very close to the result of the sulfated ash and the difference in any case was not large enough to affect the results, showing that the loss by volatization was negligible.

The following gives in tabulated form the results of resulfating the carbonated ash of six sugars and six molasses:

	Sugars				Molasses			
Sample No.	Sulfated Ash	Normal Ash	Factor	Normal Ash After Sulfating	Sulfated Ash	Normal Ash	Factor	Normal Ash After Sulfating
1......	0.36	0.27	.75	0.35	11.38	8.37	.74	11.32
2......	0.62	0.50	.81	0.65	9.79	6.83	.70	9.76
3......	0.51	0.43	.84	0.50	14.09	10.56	.75	13.90
4......	0.90	0.72	.80	0.90	13.64	9.93	.73	13.39
5......	0.73	0.55	.75	0.73	16.16	12.68	.78	16.11
6......	0.77	0.62	.81	0.72	13.38	10.83	.81	13.39
Average..	0.648	0.515	.793	0.65	13.07	9.86	.752	12.98

In a recommendation to the Committee on Revision of Methods of the Hawaiian Chemists' Association, Mr. Lynch gave the results of determinations on nine molasses, comparing the sulfated ash and the carbonated ash. He obtained a factor for conversion of .737. Mr. Lynch also sulfated the normal ash, and in all cases obtained results very close to the sulfated ash.

In view of the fact that so few references were available for cane molasses I have made analysis on over twenty-five different Hawaiian waste molasses. These samples represented molasses from twenty different factories on all the Islands. They were of varying composition. The gravity purity ranged from 27.7 to 42.8. The ash as sulfated less 10 percent varied from 8.42 to 16.19 percent. The determinations were made both for carbonated and sulfated ash.

The method used for sulfated ash was the official method of the H. C. A. The method for the determination of carbonated ash is as follows:

Weigh accurately about three grams of molasses in a weighed platinum dish. Heat carefully over a low flame till all the moisture is evaporated and the gases expelled. Place in a well ventilated muffle at barely perceptible red heat till burned to a white or light grey ash. Care must be taken that the heat is not too high.

The results are as follows:

Factory	Sulfated Ash %	Sulfated Ash Less 10% %	Normal Ash %	Percent Difference Between Sulfated and Normal Ash	Factor Required to Convert Sulfated to Normal Ash
Hakalau	11.32	10.19	8.39	25.9	.741
Honomu	13.36	12.02	9.86	26.2	.738
Hilo	10.89	9.80	8.40	22.9	.771
Onomea	11.46	10.31	8.27	27.8	.722
Pepeekeo	12.41	11.17	9.56	23.0	.770
Kahuku Strike 15–6	11.16	10.04	8.00	28.3	.717
" " 15–1	12.39	11.15	8.98	27.8	.722
" " 15–0	10.61	9.55	7.96	25.0	.750
Kahuku (Regular)	9.77	8.79	7.22	26.1	.739
Pioneer	17.99	16.19	13.74	23.6	.764
Pepeekeo	13.31	11.98	9.88	25.8	.742
Olowalu	11.56	10.40	8.53	26.2	.732
Hawi	13.08	11.77	8.95	31.6	.684
Hawi	13.11	11.80	8.98	31.5	.685
Laupahoehoe	11.16	10.04	8.19	26.6	.734
McBryde	13.20	11.88	10.16	23.0	.770
Hawaiian Sugar	14.18	12.76	10.54	25.7	.743
Union Mill	11.65	10.59	7.90	32.2	.678
Kilauea	13.54	12.19	9.67	28.6	.714
Waimanalo	11.64	10.48	8.95	23.1	.769
Koloa	12.44	11.20	9.05	27.3	.727
Kaeleku	13.74	12.37	9.66	29.7	.703
Niulii	11.14	10.03	8.05	27.7	.723
Lihue	14.69	13.22	10.74	26.9	.731
Oahu	9.36	8.42	7.35	21.5	.785

Average difference 26.6

Average factor .... .734

The factor here shown for molasses is a quite constant value. It would, however, he impossible to adopt a factor that would be exactly accurate for all molasses. It is also evident that the factor now in use, i.e. .9, is far in error. No factor that would be adopted could apply to all molasses on account of the difference in the mineral constituents of the ash. Any result reported as ash would be higher than the true mineral content of the molasses. By ash is meant not only the mineral matter but also the carbon dioxide and carbonates derived from organic material.

While making the foregoing anaylses the question was raised: How close can one check the results of a carbonate ash determination? To answer this question, two sets of comparative analyses were made on twelve different molasses, using the sulfate and carbonate methods. To obtain the comparison under average working conditions the analyses were not made in duplicate, but in different sets on different days.

The results are as follows:

Factory	Sulfated Ash Less 10%			Carbonate Ash		
	First Result	Repeating	Difference	First Result	Repeating	Difference
Pepeekeo	11.89	11.98	0.09	9.88	9.76	0.12
Pioneer	16.07	16.19	0.12	13.74	13.70	0.04
Hawi	11.77	11.85	0.08	8.95	8.95	0.00
Hawi	11.80	11.81	0.01	8.98	9.03	0.05
Olowalu	10.29	10.40	0.11	8.53	8.48	0.05
Laupahoehoe	10.04	10.03	0.01	8.27	8.19	0.08
McBryde	11.88	11.88	0.00	10.18	10.16	0.02
Kilauea	12.33	12.19	0.14	9.67	9.83	0.16
Hawaiian Sugar	12.69	12.76	0.07	10.40	10.54	0.14
Union Mill	10.59	10.51	0.08	7.82	7.95	0.13
Hilo	9.89	9.90	0.01	8.40	8.42	0.02
Hakalau	10.21	10.17	0.04	8.39	8.45	0.06
Pioneer	11.95	11.96	0.01	....	....	....
Average difference	.....	.....	0.059	....	....	0.072

The results show that the carbonate method is just as accurate as the sulfate method.

Considerable objection has been raised to adopting the method of simple incineration because it has been claimed that a clean, well-burned ash is difficult to obtain, and could not be obtained without considerable loss by volatization. I have found it little harder to obtain a good, clean ash. It does take a little longer time than by sulfating in the case of molasses. Mr. Brodie found that with sugars there was very little difference in the time required. It requires a little more attention to details of heating for the carbonated ash. I think that the objections on account of the loss by volatization are answered by the work reported in this paper.

From work done on the two methods of ash determinations the following conclusions and recommendations can be made:

That the factor for conversion in present use, i.e. .9, is far in error.

That for sugars there is quite a wide variation in the factor found for different samples.

That the factor for molasses is a comparatively constant value.

That the loss by volatization in the method by simple incineration is almost negligible.

That the results obtained by burning a carbonated ash check between themselves as well as do those by sulfating.

That for ash determinations in all sugar work the method for carbonated ash be adopted.

That where apparatus is not available and it is not feasible to run a carbonated ash, a factor be adopted that is more consistent with true values. Any factor would necessarily have to be the average figure taken from a large number of determinations. While a factor thus obtained would not be correct in all cases it would be very much closer to the true figure than the one at present in use.

That a factor of .75 could be adopted for molasses.

I would not suggest adopting any definite factor to apply to all sugars, due to the wide variations. Where a factor is desirable it should be determined from the analyses of several samples from each mill. The determinations could be made at the Experiment Station, where facilities are available for both methods.

References.

1 Ann. Chim. Physique. 1873.
2 Jl. Fab. Sucre. 1870.
3 Jl. Fab. Sucre. 1875.
4 Jl. Fab. Sucre. 1889.
5 Sucre Indigene. 1890.
6 Bull. Assoc. Chim. Sucr. 1891–1892.
7 Bull. Assoc. Chim. Sucr. 1892.
8 Centr. Zukerind. 1913.
9 Archief 1916, 24–214–216.
10 Int. Sug. Jr. April, 1922.
11 Int. Sug. Jr. 1918.
12 Revista Industrial. 1913.
13 School of Mines Quarterly.
14 Cane Sugar, page 525.

Liming Acid Lands.

Grove Farm Experiment 8, 1922 Crop.

This experiment, a continuation of the test conducted on the plant cane and reported in Record, Vol XXIII, page 84, deals with the value of sand on Yellow Caledonia cane on mauka land. The cane is first ratoons and the soil is virgin land with an acid reaction.

Coral sand was applied in three quantities, 3¼, 6½ and 9¾ tons per acre, to the plant crop. No additional sand was applied to the ratoon crop, the test on this cane being to determine the residual effect.

On the plant cane there was no appreciable difference in sand and no sand plots. The average sand plots gave 40.7 tons of cane and 4.84 tons of sugar per acre, while the no sand plots gave 41.9 tons of cane and 4.98 tons of sugar per acre.

The yields of both cane and sugar were practically the same for the average of all the sand plots and for the no sand plots in this ratoon crop, as the following table shows:

Plots	Treatment	Cane	Q. R.	Sugar
A	3¼ tons sand per acre ..	37.26	8.19	4.55
B	6½ " " " " ..	33.81	8.61	3.93
C	9¾ " " " " ..	33.33	9.49	4.01
X	No sand	35.50	8.49	4.18
	Average sand plots	34.80	....	4.16

Observations on the effect of sand on similar soil at Kilauea would lead one to believe that considerable heavier doses of sand might show some increase in yields, although the increase might not be a profitable one. In some Kilauea tests, where 10 tons of sand showed very little difference in the cane, the spots where the sand was originally dumped and which received several times as large an application, produced far better cane than the surrounding land.

Details of Experiment.

Object:

To determine the residual value of coral sand on mauka virgin land.

Location:

Field 22.

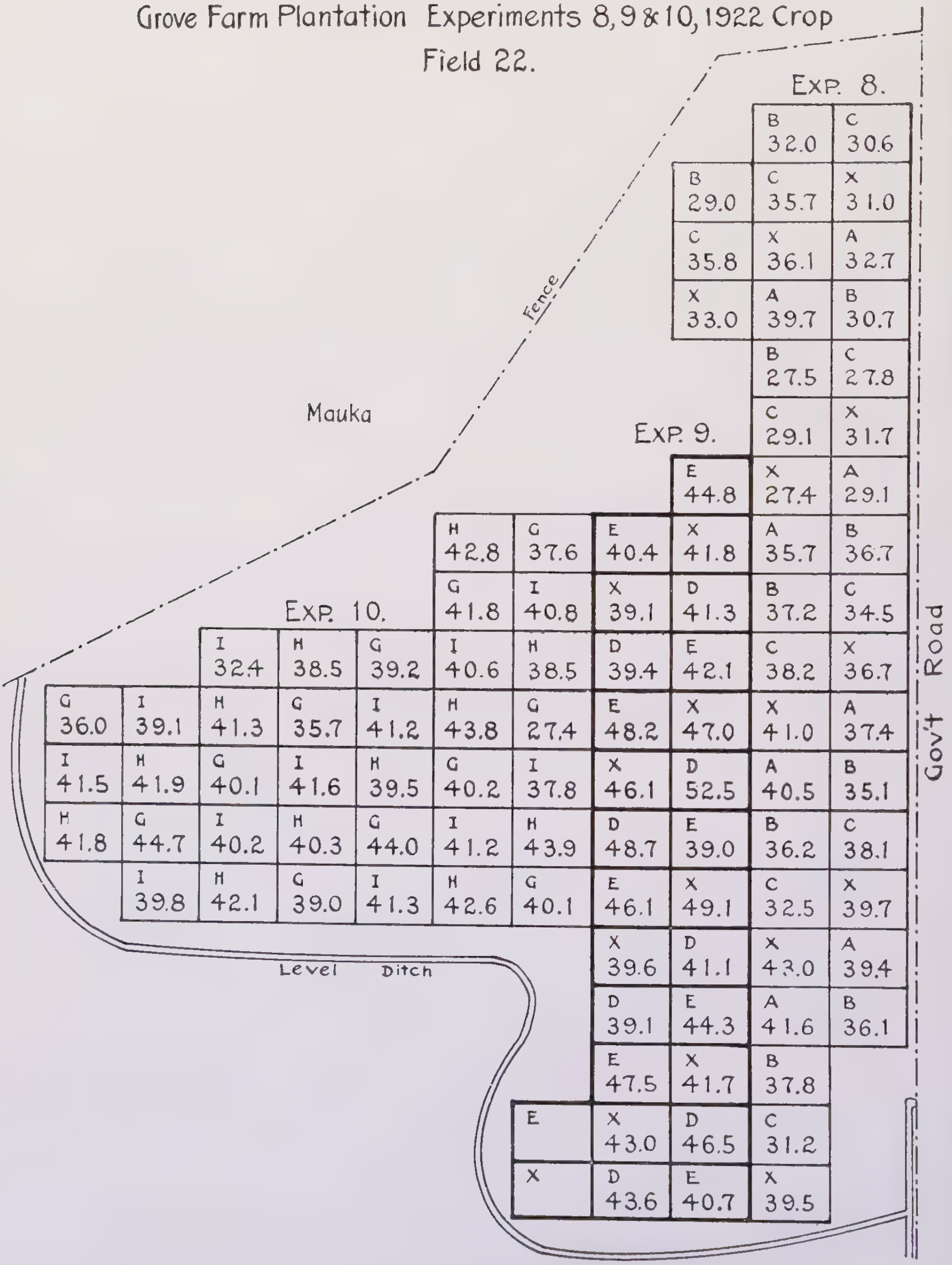
Crop:

Yellow Caledonia cane, first ratoon.

EXP. 8. SAND VS NO SAND
EXP. 9. VALUE OF REVERTED PHOSPHATE AND AMOUNT TO APPLY
EXP. 10. VALUE AND AMOUNT OF NITROGEN

Grove Farm Plantation Experiments 8, 9 & 10, 1922 Crop

Field 22.



Summary of Results (Exp. 8.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	9	$3\frac{1}{4}$ Tons Sand Per Acre	37.26	8.19	4.55
B	9	$6\frac{1}{2}$ " " " "	33.81	8.61	3.93
C	10	$9\frac{3}{4}$ " " " "	33.33	8.49	4.01
X	10	No Sand	35.50	8.49	4.18

Summary of Results (Exp. 9.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
X	9	No Phosphate	43.39	8.33	5.21
D	8	500# Reverted Phosphate	44.00	8.09	5.43
E	10	1000# " "	43.66	7.76	5.62

Summary of Results (Exp. 10.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
G	12	No Nitrogen	38.80	8.19	4.73
H	12	100# Nitrogen Per Acre	41.40	8.61	4.81
I	12	200# " "	39.34	8.92	4.41

Layout:

Number of plots = 38.

Size of plots = 1/10 acre (60 x 72.5′).

Plots are composed of 13 straight lines, 4.7′ x 72.5′.

Plots are separated by 3′ roadways running at right angles to rows.

Plan:

Plots	Number of Plots	Treatment			
		Sand per A.	Nitrogen	Phosphate	Mol. Ash
X	9	.....	150 lbs.	500 R. P.	500
A	9	6,500	150 "	500 "	500
B	10	13,000	150 "	500 "	500
C	10	19,500	150 "	500 "	500

Sand applied to plant cane, but none to ratoon crop.

Experiment originally planned and laid out by R. S. Thurston.

Experiment conducted and harvested by J. H. Midkiff.

Juice samples by A. H. Case.

J. H. M.

Mauka Soils Respond to Phosphates.

GROVE FARM EXPERIMENT 9, — 1922 CROP.

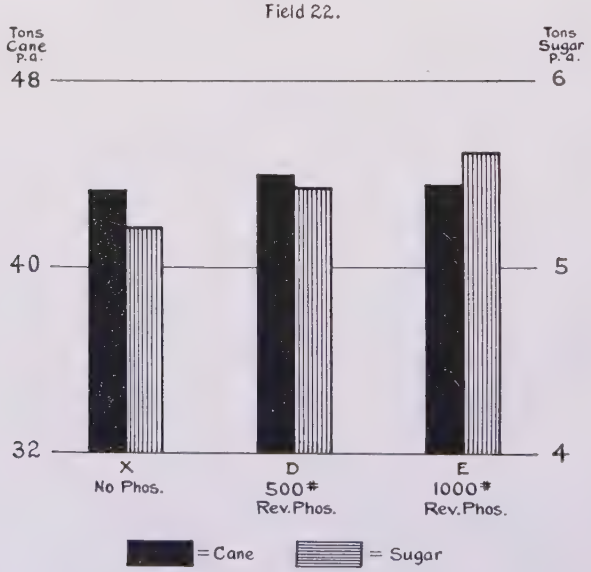
This experiment deals with the value of reverted phosphate on mauka virgin land when applied to ratoon cane of the Yellow Caledonia variety. The plant crop was harvested in June, 1920, and the results reported in Record, Vol. XXIII, page 212.

Reverted phosphate was applied to both the plant and this first ratoon cane at the rate of 500 pounds and 1000 pounds per acre. The check plots received no phosphate on either the plant or the ratoon cane.

The following table shows the results for both the plant and the ratoon crop:

Plots	Treatment	Plant Crop			Ratoon Crop			Average Gain	
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Sugar
X	No Phosphate.	42.1	8.39	5.02	43.39	8.33	5.21	....	....
D	500 R. P. p. a.	46.5	8.42	5.52	44.00	8.09	5.43	2.51	0.36
E	1000 R. P. p. a.	49.6	8.39	5.91	43.66	7.76	5.62	3.89	0.65

VALUE OF REVERTED PHOSPHATE
AND
AMOUNT TO APPLY
Grove Farm Plantation Exp. 9, 1922 Crop
Field 22.



While the yields of cane and sugar were practically as good from the ratoon as from the plant crop, the gain from the reverted phosphate was not quite as great in the ratoon crop, as a study of the above table will show. The gains

from the phosphate in both the plant and the ratoon crop were, however, profitable.

Details of Experiment.

Object:

1. To determine the value of reverted phosphate on ratoon cane on mauka land.
2. To determine most profitable amount to apply.

Location:

Field 22.

Crop:

Yellow Caledonia first ratoon cane on mauka, virgin soil, unirrigated.

Layout:

Number of plots = 27.

Size of plots = 1/10th acre (60′ x 72.5′).

Plots are composed of 13 straight lines, each 4.7′ x 72.5′.

Plots are separated by 3′ runways at right angles to the rows.

Plan:

Plots	Number of Plots	Treatment		
		Reverted Phosphate	Nitrogen	Molasses Ash
X	9	....	150	500
D	8	500	150	500
E	10	1000	150	500

Phosphate and molasses ash applied first season in one dose. Nitrogen applied in two doses, one first season and one second season.

Experiment originally planned and laid out by R. S. Thurston.
Experiment conducted and harvested by J. H. Midkiff.
Juice analyses by A. H. Case.

J. H. M.

Nitrogen at Grove Farm.

GROVE FARM EXPERIMENT 10,—1922 CROP.

This is an experiment to determine the value and the amount of nitrogen to use on ratoon cane on mauka land. It is a continuation of the experiment harvested in 1920 and reported in Record, Vol. XXIII, page 216.

The cane is Yellow Caledonia, first ratoon. The land is a mauka virgin soil and is unirrigated.

The following table shows the harvesting results from the plant crop in 1920 and the first ratoon crop in 1922:

Plots	Nitrogen	Plant Cane Harvested 1920			1922 Ratoon Crop			Average Gain From Nitrogen	
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Sugar
G	...	38.8	8.93	4.34	38.80	8.19	4.73	....	....
H	100	42.9	9.07	4.72	41.40	8.61	4.81	+ 3.35	+ 0.23
I	200	41.9	9.18	4.57	39.34	8.92	4.41	+ 1.82	— 0.04

The results of both experiments indicate very clearly that, while some nitrogen is needed for maximum crops, heavy applications are decidedly unprofitable, due to the lowering of the purity of the juices. It is probable that an application of even less than 100 pounds of nitrogen on this land would be most profitable.

Experiments upon and experience with this type of mauka soil, where the land is fallowed three years out of every nine, would lead one to believe that the plant cane should have heavy applications of phosphate with very little nitrogen. Lighter applications of phosphate and somewhat more nitrogen to the ratoon cane than to the plant cane seem to give the best results.

Details of Experiment.

Object:

To determine the value of nitrogen and the amount to apply on mauka, acid, virgin land.

Location:

Field 22.

Crop:

Yellow Caledonia cane, first ratoons.

Layout:

Number of plots = 36

Size of plots = 1/10th acre (60′ x 72.5′).

Plots consist of 13 straight lines, each 4.7′ x 72.5′.

Plots separated by 3′ roadways running perpendicular to the furrows.

Plan:

Plots	Number of Plots	Nitrogen	Phosphate	Molasses Ash
G	12	None	500 R. P.	500
H	12	100	500 "	500
I	12	200	500 "	500

Phosphate and molasses ashes applied in one dose first season. Nitrogen applied as nitrate of soda in two equal doses, one first season and one second season.

Experiment originally planned and laid out by R. S. Thurston.

Experiment conducted and harvested by J. H. Midkiff.

Juice analyses by A. H. Case.

J. H. M.

Notes on Foreign Cane Diseases.

Information on two foreign cane diseases was recently received from H. Atherton Lee, Director of Sugar Cane Investigations, Bureau of Science, Manila. In speaking of Uba cane, which shows a strong resistance to Yellow Stripe disease, and which is now being rapidly extended in Porto Rico and other points in the West Indies, he says:

> It grows vigorously during the plant crop, but is extremely susceptible to smut during the ratoon crop, which causes a total loss of the crop. For this reason, we do not believe that Uba cane is apt to succeed in those countries where smut exists.

He states that one plantation in the Philippines has given up Uba cane after growing it for three years, on account of the infestation of smut.

Concerning another malady of sugar cane which it is extremely important to keep out of Hawaii, he writes:

> We are having a good deal of experience with Fiji disease, but largely from discussion with Dr. Lyon and suggestions from Mr. Pemberton in a letter which you gave me, believe that we have it fairly well under control. At the Calamba Sugar Estate, where we organized carefully for seed selection, the disease is now negligible. We are also extending the acreage of Badila cane for seed points as far as possible, since Badila is to some extent resistant. Although we feel now that Fiji disease can be controlled, it costs money to control it, and the point for countries that do not have it is to avoid the handicap of an additional outlay for disease control.

The accompanying photographs illustrating the smut of sugar cane were furnished by Mr. Lee from the files of the Bureau of Science, Manila, P. I.

H. P. A.

At left, healthy cane; at center, two rows of smutted cane; and on right, partially smutted cane; showing the reduction from this disease. The variety in use is Uba cane.

Smut caused by *Ustilago sacchari* on Luzon White sugar cane, July, 1920.

Copy of drawing showing cane plant affected by smut. One-fourth natural size.

"H 400" Seedlings at Waipio.

Waipio Experiment R.—1922 Crop.

This was an experiment comparing Badila and seven of the so-called "H 400" seedlings with H 109. The test was carried through two crops, one plant and one ratoon.

The plant crop was harvested in September, 1920, at the age of 17 months, while the ratoons were harvested in May, 1922, when 20 months old. The plant received 190 pounds of nitrogen per acre from ammonium sulphate and nitrate of soda in two doses. The ratoons received 310 pounds of nitrogen from nitrate of soda applied in three equal doses, November, 1920; February, 1921, and May, 1921.

In neither crop did any of the varieties equal H 109 in yield. In the plant crop Badila did very well, but as ratoons this variety failed badly when compared with its H 109 checks. This was caused, to some extent, by rat and borer damage.

The yields obtained from the two crops are tabulated as follows:

Variety	Yield per Acre						Average Tons Sugar per Crop
	Plant			First Ratoons			
	Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	
H 109	77.4	7.44	10.40	93.0	7.37	12.62	11.51
H 456	65.1	7.38	8.82	85.9	8.07	10.64	9.73
H 109	71.2	7.44	9.57	95.5	7.37	12.96	11.26
H 463	72.0	8.53	8.44	93.9	8.78	10.69	9.56
H 109	70.9	7.44	9.54	94.8	7.37	12.86	11.20
H 465	60.3	7.88	7.65	84.6	8.04	10.52	9.08
H 109	73.0	7.44	9.82	98.5	7.37	13.36	11.59
H 466	69.7	9.48	7.36	89.9	8.94	10.05	8.70
H 109	62.7	7.44	8.42	87.4	7.37	11.86	10.14
Badila	58.1	6.93	8.39	60.3	8.52	7.08	7.73
H 109	78.1	7.44	10.49	99.1	7.37	13.45	11.97
H 460	70.1	8.02	8.74	80.2	10.09	7.95	8.34
H 109	77.0	7.44	10.35	91.8	7.37	12.46	11.40
H 427	65.5	8.53	7.68	50.1	10.03	5.00	6.34
H 109	75.6	7.44	10.17	107.5	7.37	14.58	12.37
H 464	61.2	7.19	8.52	64.8	9.19	7.05	7.78

In the following table the sugar per acre per month produced by these varieties is given:

Variety	Tons Sugar per Acre per Month	
	Plant	First Ratoon
H 109	0.579	0.647
H 456	0.519	0.532
H 463	0.496	0.534
H 465	0.450	0.526
H 466	0.433	0.502
Badila	0.494	0.354
H 460	0.514	0.397
H 427	0.452	0.250
H 464	0.501	0.352
Average of all except H 109	0.482	0.421

From the above table we see that H 109 and four varieties responded to increased fertilization and produced sugar faster as ratoons than as plant. The other four varieties could not do that and produced sugar very slowly in the ratoon crop.

We are continuing the three best of the above new varieties — H 456, N 463, H 465 — and have plowed up the others.

The seedlings included in this experiment are those propagated in 1911 to 1914. Some of the H 109 seedlings originated in 1918 and thereabouts, show much greater promise. A few of them show indications of becoming strong competitors of H 109 itself. Thus far these canes have not been extended to the point where large size field comparisons can be made.

J. A. V.

Early Experiments With One-eye Cuttings.

The Planters' Monthly of October, 1900, gave an account of experiments by Walter Maxwell in which different amounts of seed cane were used. The test embraced one-eye cuttings spaced at various intervals.

The results showed "that the quantity of seed planted does not determine the number of canes that are produced."

The report proceeds to say:

"One eye per 6 inches," and "per 12 inches" produces even more canes than "two continuous canes in the row." The lesser number of canes found where "one continuous row" was planted was due to the supreme action of the Rose Bamboo in crowding the Lahaina alongside of it. The number of dead canes found in the Lahaina of that test was greater than elsewhere. As many canes were produced, but they were smothered out. In the last test of "one eye per 18 inches" there were actually fewer canes produced, and the least number died out; so that in that case it is indicated that one eye per 18 inches is too wide to produce a full stand and crop. This observation will be confirmed or corrected by the new series of tests recently begun.

The number of canes produced per row or per acre from using different quantities of seed is a factor. It is not a conclusive factor, however, and in order to judge of the value of thin or thick planting we must also have the weight of cane produced, the quality of the cane juice, and, finally, the actual yield of sugar per acre.

There is very little variation in density, richness, or purity of the juice in the canes grown from different quantities of seed planted. It is observable that the purity of the juices is generally rather low for Hawaiian conditions.

The following data were presented:

Number of Tests	Quantities of Seed Planted	Canes per Row of 107½ Feet
2	Two continuous canes in row ...	382
2	One continuous cane in row	313
2	One eye per 6 inches	387
2	One eye per 12 inches	387
2	One eye per 18 inches	359

These figures show that the quantity of seed planted does not determine the number of canes that are produced.

YIELD OF SUGAR PER ACRE.

Distances of Planting	Cane per Acre	Sucrose in Cane	Sugar per Acre
Two continuous canes in row ...	185,660 lbs.	15.74%	29,212 lbs.
One continuous cane in row	193,180 "	15.31%	29,575 "
One eye per 6 inches	194,660 "	15.18%	29,549 "
One eye per 12 inches	195,940 "	15.51%	30,390 "
One eye per 18 inches	175,036 "	15.18%	26,570 "

PLANTING TESTS.

Variety	Mode of Planting	Eyes Planted	Eyes That Grew	Eyes That Died
Lahaina—				
1	Two continuous canes in row ...	2991	1179	1812
2	One continuous cane in row	1490	666	824
3	One eye per 6 inches	645	631	14
4	One eye per 12 inches	321	299	22
5	One eye per 18 inches	208	197	11
Rose Bamboo—				
1	Two continuous canes in row ...	2925	1504	1331
2	One continuous cane in row	1438	865	573
3	One eye per 6 inches	645	623	22
4	One eye per 12 inches	321	308	13
5	One eye per 18 inches	208	200	8

Lap Joints Unsuitable for Longitudinal Seams of Return-tubular Boilers.*

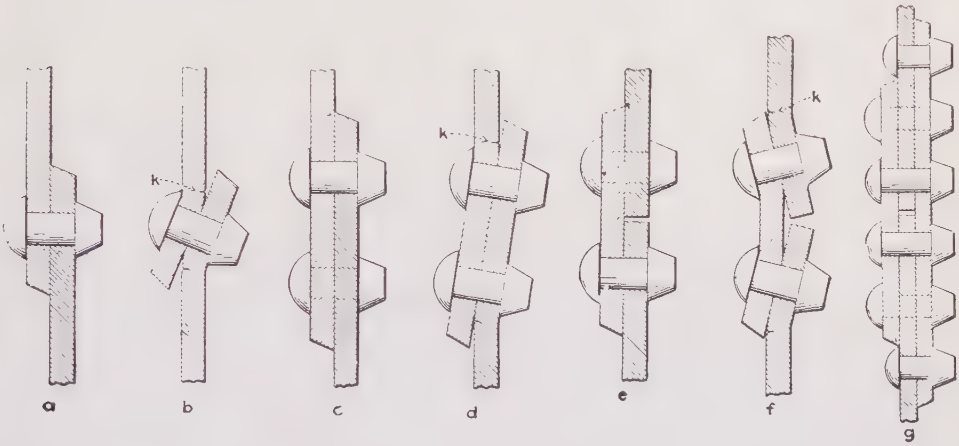
Why are lap joints prohibited and butt joints and double-strap joints required for the longitudinal seams of horizontal return-tubular boilers?

Pressure in a boiler exerts a pull or tension in the metal of the shell. In a lap joint, such as illustrated at *a* and *c*, the plates are eccentric and the stress pulling across the joint has a tendency to draw the plates into line and for the joints to assume the distorted forms shown at *b* and *d*. This bending action is less when the plates are joined with a broader lap, double-riveted, as shown at *c*, and the bending action may be reduced by bending the plates before they are riveted, but the rivets then are exposed to considerable tension as well as shearing stress, in either case the bending action is likely to open the laps and leakage and cracks are likely to occur where the distortion is most severe. The bending action comes into play every time a boiler is fired up, or with a rise of pressure, and the plates are again straightened out when the boiler cools.

With a single-strapped butt joint, such as shown at *e*, all the rivets are in single shear and there also is a tendency to bend the plates and the strap to the form illustrated at *f*.

* From "Power," July 4, 1922.

This continual bending in lap joints and in single-strapped butt joints often causes cracks *(k)* to be formed in the plates beneath the laps, and as these cracks are widened by corrosion and are hidden, they are dangerous. So many boiler failures have been traced to cracks formed in this manner, particularly with lap joints, that these joints have come to be regarded as unfit for longitudinal seams of power boilers or drums that are greater than 36 inches in diameter, and then only if the working pressure is not in excess of 100 pounds per square inch, unless staybolted.



Illustrating method of failure of lap joints. Single and double strapped butt joints.

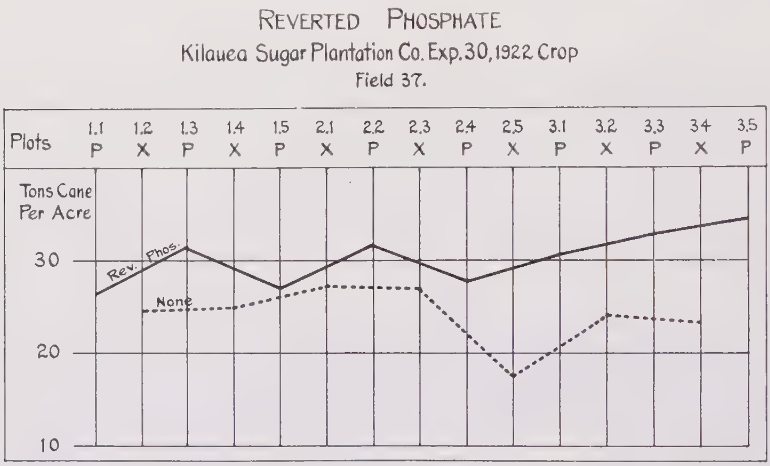
In a butt and double-strap joint, such as shown at *g*, the plates to be joined lie in line with each other, the joint is built up nearly symmetrical by inside and outside cover plates, and if the main plates and cover plates are curved to true circular form before the joint is riveted, there will be little or no tendency to bending and cracking.

[W. E. S.]

Phosphoric Acid at Kilauea.

Kilauea Experiment 30,—1922 Crop.

In this experiment reverted phosphate, applied at the rate of 1000 pounds per acre, gave decidedly profitable returns. The cane was Badila plant. The soil is heavy and one of Kilauea's most unproductive types. The field is in the mauka section of the plantation.



The cane was planted in September, 1920. The phosphate was placed in the furrow with the seed. All plots received uniform doses of molasses ashes and nitrogen. About 500 pounds of molasses ashes were applied. The cane received 150 pounds of nitrogen per acre. Seventy-five pounds of nitrogen were applied the first season in nitrate of potash. A like amount was applied the second season in nitrate of soda. The harvesting results follow:

Plots	Treatment	Cane	Q. R.	Sugar	Gain From Phosphates	
					Cane	Sugar
X	No Phosphate ...	24.19	7.76	3.11	....	....
P	1000 lbs. R. P...	30.35	8.19	3.70	6.16	0.59

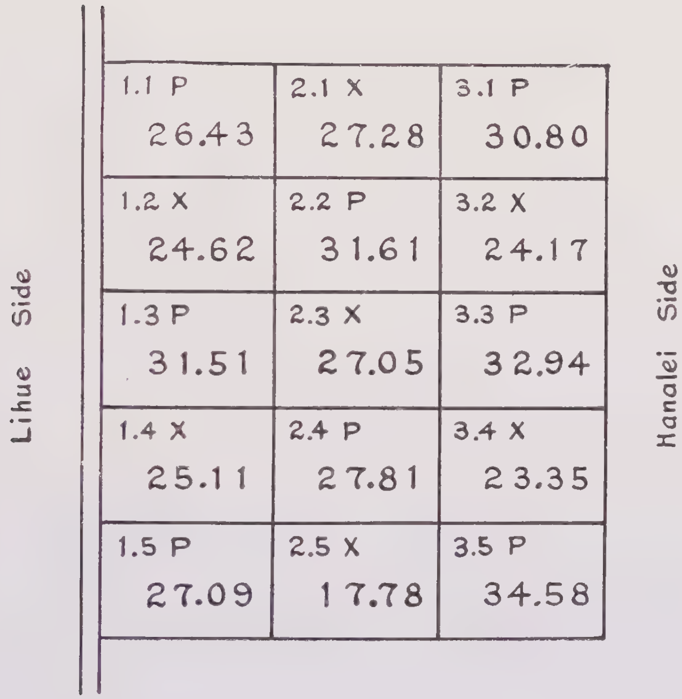
The cane in the phosphate plots had tasseled and had more lalas than the no phosphate cane. The fact that the phosphate cane was heavier had caused it to fall down more and it was consequently more rat eaten than the no phosphate cane. Eliminating the rats, there would have been an even greater gain from the phosphates.

This experiment will be carried on to determine the residual effect of the phosphates on the ratoon crop.

REVERTED PHOSPHATE

Kilauea S. P. Co. Exp. 30, 1922 Crop

Field 37.



Summary of Results

Plots	Treatment	Yields Per Acre		
		Cane	Q. R.	Sugar
X	No Phosphate	24.19	7.76	3.11
P	1000# Rev. Phos.	30.35	8.19	3.70

Details of Experiment.

Object:
To determine value of reverted phosphate when applied to Badila plant cane on mauka Kilauea land.

Crop:
Badila plant cane.

Location:
Field 37.

Layout:

Number of plots = 15.

Size of plots = 1/10 acre (80.6′ x 54′).

Plots consist of 12 straight lines, each 80.6′ by 4.5′.

Plan:

Plots	Number of Plots	Area	Reverted Phosphate	Molasses Ash	Nitrogen
X	7	0.7 acres	None	500	150
P	8	0.8 "	1000	500	150

Experiment planned and laid out by J. H. Midkiff.

Experiment harvested by J. H. Midkiff.

Chemical analyses by R. Spreckels.

J. H. M.

No Response From Potash.

KILAUEA EXPERIMENT 31, — 1922 CROP.

In this experiment exceptionally heavy doses of molasses ashes were applied to the cane. The lightest dcse applied (1000 pounds) is nearly double the ordinary plantation practice. These heavy applications were made because

AMOUNT OF POTASH

Kilauea S.P. Co. Exp. 31, 1922 Crop

Field 37.

Supply Ditch

Mauka | Makai

6.1 X 22.18	6.2 B 26.98	6.3 X 27.97
5.1 A 21.03	5.2 X 25.75	5.3 B 26.67
4.1 X 26.55	4.2 A 25.28	4.3 X 25.15
3.1 B 26.17	3.2 X 26.27	3.3 26.75
2.1 X 21.47	2.2 B 27.64	2.3 X 25.26
1.1 A 21.44	1.2 X 24.14	1.3 B 26.62

Summary of Results

Plots	Treatment	Yields Per Acre		
		Cane	Q.R.	Sugar
X	None	24.97	9.55	2.61
A	1000# Molasses Ash	23.62	9.56	2.47
B	2000# Molasses Ash	26.82	9.61	2.79

cane that had accidentally received about a ton of molasses ashes per acre had, in a previous crop of Yellow Caledonia, evidently made greater gains than the surrounding cane that received about 500 pounds per acre.

The Badila plant cane was about a foot and a half high when the molasses ashes were applied alongside the rows in September, 1920. All the cane received about 1000 pounds of reverted phosphate and approximately 150 pounds of nitrate of soda per acre. With the exception of the molasses ashes, all the cane received identically the same treatment. The soil is very heavy and unproductive and is located in one of the most unfavorable parts of the plantation.

The results follow:

Plots	Treatment	Cane	Q. R.	Sugar
X	No molasses ash	24.97	9.55	2.61
A	1000 lbs. molasses ash ...	23.62	9.56	2.47
B	2000 lbs. molasses ash ...	26.82	9.61	2.79

These results do not show that the molasses ashes give any decidedly beneficial results. One thousand pounds per acre gave less cane and sugar than no potash, while 2000 pounds gave a little more cane and sugar. A spot in the same field where piles of molasses ashes were dumped and which received, in those small areas, several tons per acre had better looking cane than the rest of the field.

This experiment will be continued to see if there are any favorable residual results from these large doses.

Details of Experiment.

Object:

To determine the value of heavy doses of molasses ashes when applied to plant cane on one of Kilauea's most mauka, unproductive fields.

Crop:

Badila plant cane.

Location:

Field 37.

Layout:

Number of plots = 18.

Size of plots = 1/10th acre (80.6′ by 54′) consisting of 12 straight lines, each 80.6′ by 4½′.

Plan:

Plots	Number of Plots	Molasses Ash	Raw Rock Phosphate	Nitrate of Soda
X	9	None	1000 lbs. per acre	975
A	4	1000 lbs. per acre	1000 lbs. per acre	975
B	5	2000 lbs. per acre	1000 lbs. per acre	975

Experiment laid out by plantation.
Experiment harvested by J. H. Midkiff.
Chemical analyses by R. Spreckels.

J. H. M.

Studies in Indian Sugar Cane, No. 4.*

[Abridged.]

By C. A. Barber.

TILLERING

In Seedlings.

The tillering or branching of the cane differs considerably according to the variety, and, as the ultimate crop of canes produced is obviously influenced by this character, it is of some importance. Scattered through the literature of the sugarcane, there are to be found many countings of shoots at various stages of growth, as well as the numbers of canes reaped at harvest, and among the records on estates a far greater number probably exist. From these observations the tillering powers of the various canes under cultivation in different circumstances have been fairly accurately determined. But, when we attempt to draw conclusions from this material, we see that the subject has rarely been treated from a scientific point of view, and in almost every case there is an absence of the careful consideration of external factors which might be expected to have influence. We still wait for an exhaustive treatment of the subject with scientific safeguards. The present paper may be regarded as, in some sort, preparatory to such work being undertaken.

It will be well, in the first place, to consider exactly what the term implies. *Tiller* is an old English word, allied to the *telgor* of the Anglo-Saxon, meaning a plant or shoot, and akin to the Dutch *telen*, to breed. At present it is, properly speaking, confined to the mode of branching characteristic of grasses. This consists in the multiplication of shoots, in the young plants, from the lower, short jointed portion of the stem, immediately below the surface of the ground. As we have noted elsewhere, this branching is the main work of the plant during its earlier period of growth. If the seed is sown too deep, one or more elongated internodes bring it to the surface, and then the joints become short and congested and branching commences. Shoots are not only given off by the main stem, but its branches may in their turn give off shoots, until a large number are produced. Branching in the upper, aerial part of the plant is less developed, occurs at a later period of growth and has nothing to do with tillering (cf Percival, *Agricultural Botany*, where the matter is somewhat fully dealt with.)

The factors influencing the amount of tillering in any plant are both inherent and external. Different species and varieties, as well as the seedlings raised in batches from the same parents, differ enormously in this character; but

* From Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X, p. 58.

this difference is often cloaked by a number of surrounding circumstances, all of which seem to be translatable into the amount of food available, and of these, space, light, water, soil, and manure appear to be the most important.

We have followed the early stages of the sugarcane seedling somewhat carefully in a previous section, and it is at once evident that this mode of branching is present in it, and therefore that true tillering occurs in the sugarcane. We usually judge of the vigor of the cane seedlings grown at the Cane-breeding Station, by counting the numbers of canes and shoots at harvest time, and we thus have a certain amount of information as to the tillering capacity of the progeny of different parents.

[The tabulated data of the original article shows the average number of canes for a number of lots of seedlings. For the thick canes the average ranges from 10 to 20, but for the thin canes the average number of sticks is much higher, 30 — 97. Extremes are recorded where there were 110 canes to a seedling stool in one case and 140 in another.

The seedlings are handled under wide spacing, being grown in pits with prepared soil or manure. Sometimes the spacing is 6′ apart, the pits being 2′ each way. Closer spacing is sometimes followed using somewhat smaller pits. Trenching has also been resorted to, the plants being spaced in the trenches so as to give 3760 plants per acre. The wider spacing above recorded furnishes only 1200 plants per acre.]

In Cultivated Canes.

With regard to the ordinary cane varieties planted from sets, it is well known that they differ a good deal in their amount of tillering. Thus the indigenous Indian canes tiller much more freely than the thicker canes of the tropics. This is the common experience of the Cane-breeding Station and, what is more, the descendants of these two classes of cane varieties inherit their parents' characters in this respect. Details regarding the Indian canes are few and far between. Practically the only comparative statement we have come across is one regarding canes grown at Sabour in Bihar.[1] In this statement it is seen that the average number of canes per clump, in the thin Indian varieties grown there is 8 — 16, in the half-thick forms (*Khelia, Striped Bansa, Puri* and *Sukli*) 7 — 8 (*Dahlsunder* 5.5), and in the thick, imported varieties, 4 — 6. It is not possible to deduce accurate acreage numbers from the table, because the details are not given of the space occupied by the clumps investigated. But the plants were put in at about 6000 to the acre, and, assuming that the countings would not be taken where clumps failed, as this would vitiate the results because of different spacing, we get, for the thin canes 48,000 — 96,000 canes per acre, for the half-thick, 42,000 — 48,000 and for the thick, 24,000 — 36,000. The latter figure tallies fairly well with those obtained for the cane varieties grown in the tropics. Numerous data can be obtained for these, and I have selected a few at haphazard from various sources.

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[1] Woodhouse, Basu and Taylor. The distinguishing characters of sugarcanes cultivated at Sabour. *Mem. Dept. Agr. Ind., Bot. Ser.*, Vol. VII, No. 2, April, 1915.

Louisiana: *Purple* cane, 35,000.

Java: *Cheribon,* 20,000; *J. 247,* 31,500; *J. 36,* 32,000; *J. 100,* 28,600.

Madras (Godavari delta): *Namalu,* 25,000; *Mogali,* 20,000; *Keli,* 31,000; *Seema,* 22,000; *Yerra,* 37,500, etc.

In almost all of these cases we note that, the thicker the cane, the fewer there are to the acre, and the general observation of this fact has led various writers to suggest that, given similar conditions of soil, climate and treatment, practically the same weight of cane may be reaped per acre whatever the variety may be. This principle appears to be fairly well established, provided that the cane varieties compared belong to the same natural class. A rather striking confirmation of this principle, that thickness and canes per acre are negatively correlated, may be seen in the following table, the details of which have been extracted from Memoir III, where the Saretha and Sunnabile groups of canes are contrasted. These canes were all grown on adjacent plots under the same conditions.

Saretha Group			Sunnabile Group.		
Variety	Canes per Clump	Thickness in cm.	Variety	Canes per Clump	Thickness in cm.
Chin	29	1.5	Kaghze	20	1.6
Saretha (green)......	28	1.7	Bansa	18	1.8
Khari	24	1.8	Sunnabile	17	1.9
Hullu Kabbu	22	1.9	Naanal	15	2.1
Ganda Cheni (poor)..	16	2.0	Dhor (poorly grown).	12	2.2
Average	24	1.8	Average	16	1.9

In this table the varieties of each group (all that were measured) are arranged in order of tillering power and, in the second column, where the relative thickness of the canes is given, the order is seen to be exactly reversed. Too much weight must not, of course, be attached to this interesting result, for the relative differences are by no means proportional, and a comparison of the averages of the two groups is instructive as showing that the class of cane has influence; but a similar result, with many exceptions, is to be found in the longer tables appended, of thickness and tillering power of the varieties of the different groups in the 1917–18 crop on the Cane-breeding Station.

[The table here referred to is not reproduced. It shows a long list of Indian varieties grown under different conditions of cultivation, irrigation, manuring, and spacing. The average number of canes per acre ranges from 49,000 to 151,680. The statement is made that these figures are not from actual counts, but from calculations based on the number of sets planted. Where sets have died out an error is introduced into the estimates as given.]

Tillering and thickness of cane are inherent characters in each variety and group, but we must limit their correlation to the members of the same group. Thus, the Mungo class are among the thickest of the indigenous canes, being

short and bush-like, and their tillering power is very great; on the other hand, the Nargori group contain, on the average, the thinnest Indian canes, and their tillering power is practically the same in the table as that in the Mungo class. Mere thickness cannot therefore be taken as a character from which tillering power can be deduced, but the group character must also be taken into account. In these and other comparisons the thick canes, tropical, are generally taken as one class, because there is at present no classification prepared for them, as for the Indian canes. It is certain that great differences exist, which should be worked out in order to introduce a proper classification in them also. (See, however, Jeswiet's recent papers on this subject, where a series of descriptions of thick canes has been commenced.)

Taking this character of tillering as inherent in the variety, this variation is not surprising, for we have found similar differences to occur in almost every other character of the cane. The comparison of such other characters has been prosecuted for several years, and it is hoped will form the subject of another Memoir shortly. The length and thickness of the cane, the number of joints, the relative length of cane and shoot, the width and length of the leaf, the rate of maturing of the cane and the number of dead leaves adhering to the stem at different periods of growth, all of these characters have been found to vary profoundly, in the same cane, in different localities in India, and we have noted that the locality impresses itself on the plant produced to such an extent, that a survey of the series of measurements will generally enable us to determine in what part of the country the cane has been grown. A large number of deductions could be drawn from this table of tillering, but it is felt that these are foreign to our present purpose and, also, that the figures having been obtained for one year only, require confirmation and extension and it is hoped that this will be done by those in charge of the various farms. It may be noted in passing, however, that one of the most interesting results obtained is the way in which certain varieties seem to be adapted to certain localities, an aspect of the question which will be dealt with in the Memoir proposed.

The following summary table shows that, with the exception of Mungo and the green section of Saretha, the average thickness of the canes in a group varies more or less inversely with the rate of tillering.

Name of Group	Number of Varieties	Average Thickness in cm.	Average Number of Canes per Clump
Mungo	32	2.60	15.10
Nargori	13	1.60	15.10
Saretha (brown).......	13	1.62	14.00
Unclassified list	21	1.87	13.60
Sunnabile	22	1.90	12.55
Pansahi	17	1.95	11.00
Saretha (green)........	10	1.86	9.50

Deaths During Growth and the Period of Maximum Tillering.

In considering the tillering power of different varieties of canes, founded on the number of canes produced at harvest, it is necessary again to sound a note of warning at the somewhat loose use of the term in general practice. The total number of canes at crop time is not in reality a safe guide to the shooting power, or tillering capacity in its narrower sense, because a large number of shoots die during the life of the plant. This is a necessary result of cultivation, where a tufted grass is forced to grow within narrow limits, so as to obtain as many matured stalks as possible. There is not room for the development of a number of the shoots formed and hence the mortality among them is very considerable. Stubbs in his careful experiments on the *Purple* and *Striped Louisiana* canes in 1894-95, calculated that the deaths of shoots during growth were 58.9 per cent. in 1894 and 53.9 per cent. in 1895. Muller von Czernicki, in Java, counted the number of shoots appearing above ground at varying periods between 60 and 150 days, and showed conclusively that the numbers were far greater at the earlier than the later period. Thus, in *Cheribon* 120 — 180 shoots were counted in different plots at 60 days from planting and only 60 — 70 at 150 days; the figures for *J. 247* were 160 — 240 and 90 — 100, and for *J. 100,* 100 — 170 and 82 — 86 respectively. Struben, in a series of experiments on *J. 247,* found that the better grown plots in the first two or three months gave 300 — 400 shoots per row, in one case the number reaching 415, whereas at eight months all of the rows gave only about 110 shoots. No data are as yet available as to whether Indian canes suffer this great mortality during the earlier period of growth, but there is some reason to suspect, from shoot-counting observations, that it is a much less serious factor than in the thick canes, and further countings have been commenced to settle the question.

Another point to be held in view is the relative rate of germination and tillering in different varieties. This of course does not refer to the effect of cold and drought, as for instance in North India where the early growth is so much slower than in the Indian Peninsula, but only includes comparisons where the conditions are altogether as similar as it is possible to make them. We find that there is a considerable variation in different canes in this respect, as can be readily demonstrated in comparing the Saretha and Sunnabile varieties on the Cane-breeding Station (cf. Mem. III, p. 149). Muller von Czernicki found in his shoot-counting experiments, that *Cheribon* reached its maximum number of shoots in 60 days from planting, *J. 100* at 90 days, while *J. 247,* although having more canes at harvest than either of the others, was slower and later in its earlier stages. In comparing the maximum number of shoots formed in any variety, it is not safe, then, to count the number of shoots in the plots at any one time, but the rate of development must be held in view, so as to get a true maximum for each variety, and from this to deduce the number of deaths occurring. For a time the numbers of shoots formed exceed the deaths and the total numbers steadily rise in the plots, but a period soon supervenes where

there are many more deaths than new formation and, once this period has been reached, there is a continuous and great reduction in total numbers; later on, a sort of equilibrium is reached, when the activity of fresh formation wanes and the shoots are of sufficient vigor and size to be able to maintain themselves and grow to maturity.

Artificial Interference With Tillering.

The great mortality of shoots during growth is obviously of serious import from the crop point of view. Not only is the possible number of canes diminished, but the formation of such numbers of abortive shoots must be a serious drain on the reserves of the plant. Attempts have accordingly been made from time to time to limit the tillering of the sugarcane by artificial means. It is the common practice with many crops to thin the plants out when they have become established, thus assuring a full stand with plenty of room for the development of each plant. This practice is hardly applicable to the present case, which is more analogous to the thinning out of branches in pruning and removing an excessive number of fruits or flowers for the better development of those that remain. Rosenfeld conducted some experiments at Tucuman on the effect of the thinning out of cane shoots on the crop, but found that the results from this procedure were rather adverse than otherwise.[1] These experiments are, however, open to serious criticism and cannot be regarded as demonstrating the inadvisability of the practice of thinning. His experiments were conducted on a single plot of canes, half of which was thinned and the other left intact. There was no control or duplicate plot. He repeated the thinning operation each year on the same plot, where the canes were grown, to first, second, third and fourth ratoons. It would be a mistake to assume that these successive experiments on the same plot were in any way a substitute for proper control plots, in that any fault in the original selection would but be repeated each year. Besides this, it is quite possible that ratoons may behave differently to plant canes in this matter, and also among themselves, whether first ratoons or those of a higher order. No hints are given as to the character of the season in each year, although there are instrinsic evidences that these differed, and it is quite reasonable to suppose that the thinning would have a different value according to the season, and consequent general health and growing of the plants. Lastly, no preliminary experiments appear to have been made at the correct time of thinning. The plot was planted in June, it was thinned in March "where it was thought necessary," "by removing suckers and small canes where there was an abundance of larger better-grown stalks," and the crop was reaped in July. It would seem natural that this late removal of small canes would act prejudicially on the weight of the crop at harvest, and the canes were also naturally, on the average, thicker as well as fewer in the thinned plots. For a decisive result on the effect of thus artificially restraining tillering, the thinning should be carried out sys-

[1] Rosenfeld, A. H. Experiments in thinning out sugarcane rows. *International Sugar Journal*, 1914, p. 220, and 1918, p. 20.

tematically throughout the plots, separate plots should be thinned at different periods of growth, and a reasonable number of controls should be introduced.

In Louisiana, profuse tillering is a matter of some moment because of the shortness of the season. For the best results to be obtained, it should be great in the earlier part and small or absent at the end of the season. This has been very clearly explained by Stubbs,[1] and a further danger in later tillering has been pointed out by him. Shoots developed after July 1 are not likely in Louisiana usually to mature before the cold weather sets in. Furthermore, late tillering and shooting of the aerial buds destroys the evenness of the stand in the ratoons of the following year, as these are (presumably) killed during the cold weather. Stubbs therefore paid very marked attention to the matter for several years, and adopted various methods which, he thought, might regulate the branching of the cane at different periods of growth, his desire being to stimulate the early and restrain late formation of branches. His general conclusions are summed up in the statement that tillering is a natural property of the cane and cannot be prevented. As the result of his experiments he, however, suggests that continued working between the rows without injuring the roots might act as a restraining influence on too late branching.

The earthing up of the cane rows is a well-known practice, both for the purpose of drainage and the provision of suitably prepared nutriment, and for giving the plants a firm hold on the ground when they are tall and stormy weather prevails. It is customary in Java for this operation to be performed at stated intervals, and there appear to be four successive earthings up, during the first four or five months of the plants' growth. This practice, as with all the agricultural operations on the cane field, is doubtless the result of numerous careful experiments during past years. From what we have stated regarding the different phases of growth in grasses, we should naturally assume that the heaping of earth over the base of the cane plant would, by lengthening the period of underground branching, tend to increase the tillering. But it seems to be held by many in Java, that earthing up tends rather to restrain tillering. As, however, the opinions expressed from time to time have been very conflicting, Struben [2] and others have conducted experiments to see if tillering was affected by delaying the earthing up. Struben's general conclusion is that the time of earthing up has little or no effect on the general crop result. In another paper he deals with other matters, such as manuring and spacing, and comes to the same general negative result, and it is worth while drawing attention to the fact that he would almost seem to hold a brief for the non-effect of these various operations, whereas it occurs to us as quite possible that another worker might have come to a somewhat different conclusion on the facts quoted by him. We shall refer to this in more detail later on.

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1 Stubbs, W. C. *Sugarcane,* Vol. 1, Chapter XIV, Suckering of cane.

2 Struben, W. Vroege of late aanaarding? *Archief,* v. d. *Suikerind.* in *Ned. Ind.,* Bijblad, 1909, p. 592.

On the Factors Influencing Tillering.

Of all the facts influencing tillering, perhaps the most important is light, but the provision of other needs of the growing plant, such as warmth, moisture, soil constituents and manuring, must also be considered. Lastly, the space available is of immediate effect, because of the interference of the shoots with one another and the varying amount of light and food in all its forms which may be obtainable. It should be obvious that tillering, being an essential characteristic of the growth of the plant, will be assisted by anything that induces a better physical condition.

The Influence of *Light*. We have seen that deeply planted grass seedlings at once set about an attempt at reaching the proper place for tillering, near the surface of the soil. A similar contrivance has been shown to exist in certain young sugarcane seedlings [Vol. XXVI, p. 254, *Record*], but observations have not been recorded as to this habit in deeply planted sugarcane sets. In our dissections, however, we not infrequently meet with what might be termed upright runners, in which long, thin internodes are intercalated between the usual congested short internodes of the base, and doubtless the meaning of this is sometimes the same as that in seedlings, in that thereby the underground part may be placed in the best position for rapid branching, near the soil surface. Tillering cannot take place satisfactorily unless the shoots are able immediately to emerge into the light. But when a certain number of branches have been developed, and the light space so to speak is filled, further shoots are at a disadvantage in that they are overshadowed by their neighbors. This is undoubtedly the cause of the great mortality in cane shoots during the growth of the crop, and it is not easy to see how this perfectly natural effort at producing as many branches as possible can be prevented, if the plant itself has not the power to adapt itself to the conditions. It is fairly certain that this death of shoots is not due to the lack of food supply in the soil, for this can be, and habitually is, supplied to meet all possible needs. Generally speaking, all plants in the light branch more freely than in the shade. Growth in length is repressed in light and a more spreading habit is induced which gives room for more shoots to be developed. As one author has justly argued, of all the food producers on which the plant is dependent, light is the only one over which we have no control. There is a definite amount of light available for each area, and this we cannot increase by any means, whereas air is moving, and water and salts can be applied artificially. We can increase the depth of soil and the amount of water, can improve the physical condition of the soil and add manures as desired, but as soon as the amount of light available is fully occupied, the further branches are shadowed and unhealthy, however many we may by various means cause to be developed. It is a common experience that trees on the outside of a forest, or in free space, are much larger and more uniformly developed than those within the forest, and this is not only due to their greater command of the soil around, but also to the light available, and the same applies to cane plants near the edges of the fields or along the sides of the paths. The problem of obtaining the greatest number of canes per acre is thus seen to be strictly limited by this factor, as

well as by those of cultivation and manuring. Light is perhaps the most important limiting factor as regards tillering.

Moisture also undoubtedly affects tillering, as can be seen by studying the plants along the irrigation channels where they are as closely planted as elsewhere. The frequent advantage of plants so situated should be carefully noted, as suggesting that full use is not always being made of watering facilities. There is still a good deal of work to be done with regard to the effect of the duty of water on the number of canes to be obtained under varying conditions of soil and manuring.

Manuring naturally has its effect on the number of canes produced as well as their individual weight and the richness of their juice. A careful study of this effect has been made by Kilian, who desired to know the best manure to be applied to the three cane varieties which appeared to be suited to the different soils in his estate at Poerwodadi in Java.[1] Although his research was limited to a purely utilitarian problem, the care with which his experiments were conducted renders them valuable from the scientific point of view, and their limited range is of no disadvantage in this respect. The experiments were with *Black Cheribon* and *J. 247,* which were canes growing well in his conditions, and consisted of a series of plots to which were added varying amounts of sulphate of ammonia, superphosphate and cattle manure. Besides studying general yield and other matters, he counted the number of canes at harvest, and this renders his paper of interest to us. Briefly the results were as follows:

In *Black Cheribon,* with the same amount of sulphate of ammonia, increasing doses of superphosphate gave a gradual rise in the weight of cane and of sugar per acre; also there was an increase in the number of canes, but this was less regularly the case. With increasing doses of sulphate of ammonia, the numbers of the canes varied irregularly, whereas the weight of canes and of sugar gradually increased. With the addition of a suitable amount of cattle manure to a moderate amount of both of these artificial manures, there was a distinct rise in the numbers of canes in the plots, as well as weight of cane and of sugar at crop time. The experiments with *J. 247* seem to have been confined to the ammonium sulphate series, and the results were similar to those with *Black Cheribon.*

These experiments were carried out on soils varying from heavy black clay to thin dry loam, and we see that the addition of quantities of suitable manure, especially cattle manure, lead to a distinct increase in the number of canes. It seems probable that similar results would be obtained in other places, once it is determined in what direction the manurial constituents of the soil are lacking. Kilian's results on the numbers of canes are summarized in the following table:

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[1] Kilian, J. Bemestings-en plantverband-proeven op de S. F. Kanigoro, oogst 1908–9, *Archief* v. d. *Suikerind.* in *Ned. Ind.,* Vol. XVIII, p. 566. 1910.

NUMBER OF CANES PER BOUW (1¾ acres) WITH DIFFERENT MANURES.

Experiments With Super and Cattle Manure: Black Cheribon.

Manure	Thin Dry Loam	Dry Loam	Heavy Black Clay	
4 pik. sulph. am.	33,011 slight fall *	38,261	28,772	39,204 irregular
do. + 1 pik. super			34,367 slight rise	
do. + 2 pik. super	36,045 rise			
do. + 3 pik. super		40,562		
do. + cattle manure	37,698		36,642	42,865

Experiments With Sulphate of Ammonia and Cattle Manure on Dry Loam.

Manure	J. 247	Cheribon
3 pik. sulph. am.	57,135 irregular	34,559 irregular
4 do.		
5 do.		
6 do.		
4 do. + cattle manure	60,934	35,177

* The words "slight fall," "rise," etc., below an average figure, indicate any changes within the bracketed treatments.

Kobus[1] in an earlier paper (1905) describes the results of his experiments on growing cane uninterruptedly on the same land for a succession of years, with a various assortment of manures designed to take the place of rotation and fallowing. In this series were N, N and P, N and K, N, K and P, and all these with or without the previous addition of Ca. The series is a very full one, as it deals with three different varieties of cane, J. 247, J. 33a and J. 36. He states that the plots were much affected by the weather, there being a severe drought in the earlier part of the season, but that they recovered much better than he had expected. There were, however, many failures in germination, varying from 6.4 per cent. to 12.4 per cent. in the different varieties. Rats invaded the plots and created great havoc, to an extent in some cases of 40 per cent. Lastly, J. 36 suffered from red rot, as this variety is more liable to the disease than the others. Among other data, he obtained the number of canes in each plot, and his general conclusions were that tillering is comparatively

[1] Kobus, J. D. Cultur van suikerriet zonder tusschen-gewassen. *Archief* v. d. *Java Suikerind.* Vol. XIII, 1905, p. 485.

unaffected by manuring. By this we presume that he means rather that the *kind of artificial manure applied*, whether nitrogen, potassium, phosphorus or calcium in their various combinations, has little effect on the number of canes produced per acre. This does not seem to be quite the same position as that taken by Kilian and, for the present, his more special work seems to be more to the point, as it deals rather with the quantity of suitable manure than the kind of manure applied.

Struben,[1] in 1911, asserts that there appear to be no definite experiments

1911, p. 487.

on the effect of manuring on tillering. This seems rather strange, in view of his later quoting from both Kobus and Kilian. He states that he has often noted that very heavy manuring does not affect tillering, although he does not himself experiment in the matter. As we have pointed out above, Struben assumes the attitude that no appreciable alteration is made in tillering by various changes in cultivation, whether spacing, earthing up or manuring, and for this dictum he seems to depend on a generalization of Kobus, made in his 1905 paper, referred to above, that "with a difference of even 10 per cent. in the numbers of canes in a plot, there *may* be a similar outturn of sugar at crop time." This perhaps will throw light on Struben's attitude and, when he asserts that the number of canes is not influenced by manuring, he may mean that, as far as total sugar obtained is concerned, such differences as are noticeable are of little consequence. With this aspect we are at present not concerned, and have little hesitation in concluding that manuring has an influence on tillering, as well as any other means by which the healthiness and vigor of the plant is enhanced.

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1 Struben, W. Uitstoeling. *Archief v. d. Suikerind. in Ned. Ind.*, Vol. XIX, Part 1,

(To be continued.)

Sugar Prices.

96° Centrifugals for the Period

June 16 to September 15, 1922.

Date	Per Pound	Per Ton	Remarks
June 16, 1922 ...	4.61 ¢	$ 92.20	Cubas.
" 19	4.625	92.50	Porto Ricos.
" 20	4.73	94.60	Cubas.
" 22	4.86	97.20	Philippines.
" 26	4.77	95.40	Spot Cubas.
" 27	4.73	94.60	Cubas.
" 30	4.80	96.00	Cubas. Market holiday Friday night until Wednesday morning.
July 5	4.75	95.00	Porto Ricos.
" 6	4.99	99.80	Cubas 4.99, Porto Ricos 5.00, Philippines 4.98.
" 7	5.025	100.50	Cubas 5.05, Porto Ricos 5.00.
" 10	5.00	100.00	Porto Ricos.
" 11	4.99	99.80	Cubas.
" 12	4.93	98.60	Spot Cubas.
" 13	4.905	98.10	Cubas 4.92 and 4.89.
" 14	4.89	97.80	Cubas 4.86 and 4.92.
" 17	5.00	100.00	Porto Ricos.
" 18	5.0533	101.06	Porto Ricos 5.00, Cubas 5.11, Porto Ricos 5.05.
" 19	5.24	104.80	Cubas.
" 21	5.22	104.40	Cubas.
" 25	5.345	106.90	Cubas 5.36 and 5.33.
Aug. 7	5.36	107.20	Spot Cubas.
" 15	5.30	106.00	Spot Cubas.
" 16	5.25	105.00	Spot Cubas.
" 18	5.15	103.00	Spot Cubas.
" 21	5.11	102.20	Spot Cubas.
" 22	5.0575	101.15	Spot Cubas 5.11, 5.08, 5.03, 5.01.
" 23	4.9425	98.85	Spot Cubas 5.01, 4.88, 4.89; Cubas 4.99.
" 24	4.80	96.00	Spot Cubas.
" 28	4.955	99.10	Cubas 4.92 and 4.99.
" 29	4.99	99.80	Cubas.
" 31	5.25	105.00	Spot Cubas 5.25, 5.26; Cubas 5.24.
Sept. 1	5.24	104.80	Cubas.
" 5	5.24	104.80	Spot Cubas.
" 7	4.99	99.80	Cubas.
			[Beginning Sept. 9, Saturday market days resumed. Basis 4.99, no sales.]
" 14	4.86	97.20	Cubas.
" 15	4.73	94.60	Cubas.

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